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SERIES E: OVERALL NETWORK OPERATION, TELEPHONE SERVICE, SERVICE OPERATION AND HUMAN FACTORS

Quality of service, network management and traffic engineering – Traffic engineering – Measurement and recording of traffic

Traffic intensity measurement principles

ITU-T Recommendation E.500

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION E.500

TRAFFIC INTENSITY MEASUREMENT PRINCIPLES

Summary

This Recommendation describes traffic intensity concepts and traffic intensity measurement methodologies. The concepts of normal and high load are described and the methodology for using these measured traffic intensities in determining the load for traffic system dimensioning is discussed.

Source

ITU-T Recommendation E.500 was revised by ITU-T Study Group 2 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 9th of November 1998.

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.

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 term *recognized operating agency (ROA)* includes any individual, company, corporation or governmental organization that operates a public correspondence service. The terms *Administration, ROA* and *public correspondence* are defined in the *Constitution of the ITU (Geneva, 1992)*.

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As of the date of approval of this Recommendation, the ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

CONTENTS

Recommendation E.500

TRAFFIC INTENSITY MEASUREMENT PRINCIPLES

(revised in 1998)

1 Scope

This Recommendation considers traffic intensity measurements for traffic systems consisting of a pool of resources and random arrival events that require the use of some amount of resources from the pool for some period of time. Traffic systems with and without waiting room (i.e. queueing) are considered. Only traffic systems with a pool of resources of a single type are considered. The defined traffic intensity measurements relate to the use of stationary arrival process models to characterize traffic over the measurement intervals.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

– ITU-T Recommendation E.492 (1996), *Traffic reference period.*

– ITU-T Recombination E.501 (1997), *Estimation of traffic offered in the network*.

– CCITT Recommendation E.503 (1992), *Traffic measurement data analysis*.

– CCITT Recommendation E.504 (1988), *Traffic measurement administration*.

– CCITT Recommendation E.506 (1992), *Forecasting international traffic*.

– CCITT Recommendation E.507 (1988), *Models for forecasting international traffic*.

– CCITT Recommendation E.508 (1992), *Forecasting new telecommunication services.*

– ITU-T Recombination E.600 (1993), *Terms and definitions of traffic engineering*.

3 Definitions

This Recommendation defines the following terms:

The **Daily Peak Period (DPP) traffic intensity measurement method** is the method in which traffic intensity is measured for consecutive read-out periods of each day, and the peak traffic intensity for the day is recorded. This method requires continuous measurements.

The **Fixed Daily Measurement Interval (FDMI) traffic intensity measurement method** is the method in which a predetermined time interval (i.e. a set of consecutive read-out periods during a day) in which peak period loads usually occur is identified, and during that time interval each day traffic intensity measurements are taken. The peak traffic intensity over the measured read-out periods is recorded for the day.

Normal load condition identifies frequent busy operating conditions of the network for which user expectations should be met.

High load condition identifies not very frequently encountered operating conditions for which user service expectations would not necessarily be met, but for which the level of performance achieved should be high enough to avoid significant user dissatisfaction, spread of congestion, etc.

Normal (high) load traffic intensity is the representative value over a monthly time interval of the traffic intensity under normal (high) load condition.

Yearly Representative Value (YRV) of the normal (high) load traffic intensity is the representative value over a yearly time interval of the traffic intensity under normal (high) load condition.

Other definitions follow Recommendation E.600.

4 Abbreviations

This Recommendation uses the following abbreviations:

CPU Central Processing Unit

DPP Daily Peak Period

FDMI Fixed Daily Measurement Interval

GOS Grade of Service

YRV Yearly Representative Value

5 Traffic intensity concepts

5.1 Background

In a broad sense, traffic intensity relates to the rate that work arrives to a traffic system and the resources needed to handle the work. The class of *traffic systems* under consideration in this Recommendation consists of a pool of resources of a single type, jobs that arrive and seize a needed amount of resources or wait until they are available (or leave if there are insufficient available resources and insufficient waiting room), and a holding time per job, which is the time a job requires from a specified quantity of dedicated resources to complete its work. Some important examples are:

- Circuit Groups – The job is the call, the resources are the specified number of circuits required by the call, and the holding time for a job is the call holding time.
- Call Processing – The resource is a call processing CPU, the job is a call, and the holding time for the job is the CPU processing time for the call.
- Packet Data Transport – The resource is a fixed bandwidth data transmission channel, the job is to transport a data packet over the transmission channel, and the holding time for a job is the time it takes to transmit the packet (i.e. [packet length]/[data channel speed]).
- B-ISDN network – Consider an ATM link in which the Connection Admission Control (CAC) assigns a certain fixed bandwidth to each arriving connection. It behaves as a traffic system in which the job is a connection, the resource is the bandwidth assigned by the CAC to the connection and the holding time for a job is the connection holding time.

Average traffic intensity is measured over time intervals which are called *read-out periods* (see Recommendation E.492). The length of the read-out period must be chosen so that acceptable estimates of traffic intensity are obtained. Specific considerations that must be made in choosing the read-out period are given in 5.5.

5.2 Traffic intensity concept and stationarity

Instantaneous carried traffic intensity is defined in Recommendation E.600 as the amount of occupied resources in a traffic system at a given instant. Instantaneous offered traffic intensity is the amount of occupied resources in a traffic system with infinite resources. Average traffic intensity is defined as the time average of the instantaneous traffic intensity over a period of time. The variation of the instantaneous traffic intensity over time is called the traffic intensity process.

This Recommendation deals with situations in which the traffic intensity process can be considered stationary, that is, there are stationary traffic intensity models that are a good approximation to the actual traffic intensity process[1]. For the traffic intensity process to be considered stationary in a read-out period, it is necessary that:

a) the job arrival process can be considered stationary;

b) the job departure process can be considered stationary;

c) both the arrival and departure processes have the same mean rate during the read-out period.

When the average job holding time is much smaller than the read-out period, conditions b) and c) are satisfied in most practical situations if condition a) is satisfied. In this case, the average traffic intensity is given by:

$$A = \lambda \cdot n \cdot h \tag{1}$$

where λ is the average job arrival rate, n is the average number of dedicated resources per job, and h the average resource holding time per job (weighted with the number of resources needed by the job).

If the mean holding time is of the order or greater than the read-out period, equation (1) may not hold even though the traffic intensity process can be approximated by a statistical model. An example of this situation is illustrated in Annex A.

5.3 Assumptions for this Recommendation

In order for the methods used in this Recommendation to be valid, the following assumptions must be satisfied:

1) A read-out period length can be chosen such that there is, for each observed read-out period, a stationary model that is a good approximation to the actual traffic intensity process observed.

2) If the model of the traffic intensity process has parameters in addition to traffic intensity (e.g. peakedness or variance measures), those parameters are obtained by methods that are not covered in this Recommendation.

3) When there are additional parameters, as identified in Assumption 2, the worst case situation for dimensioning resources always occurs when the traffic intensity is highest.

[1] A good approximation means that when the traffic intensity model parameters are set to produce the measured traffic intensity over an observed read-out period, and this traffic model is used to predict system performance over the read-out period, the predicted performance is (for dimensioning purposes) within acceptable limits of accuracy from the observed performance.

4) Exceptional read-out periods that violate Assumption 1 (e.g. the observed arrival process is highly non-stationary) should be detected and excluded from being considered.[2]

5.4 Measured traffic intensity

Consider a traffic system and let $W(t_1,t_2)$ be the total work done[3] over the time interval (t_1,t_2). The *measured traffic intensity* over the time interval (t_1,t_2) is defined as:

$$A(t_1,t_2) = W(t_1,t_2)\,/\,(t_2 - t_1) \tag{2}$$

The unit for measured traffic intensity is the erlang, and (2) represents the average number of busy resources over the time interval (t_1,t_2).

If the traffic system blocks some of the arrivals, the measured traffic intensity is a measure of *carried load* and not of the offered load. With negligible blocking, the measured traffic intensity is also a measure of the offered load. For dimensioning purposes, the need is to dimension for offered load, so it is desirable for the measured traffic intensities used in dimensioning to capture the offered load. If there is significant blocking present when traffic intensities are measured, some method should be used to estimate the blocked traffic intensities so that as good an estimate as possible of the offered load is determined. Recommendation E.501 provides procedures for estimating the traffic offered to a circuit switched network.

To use (2) to measure traffic intensity, it is necessary to measure the actual resource usage $W(t_1,t_2)$. An alternative frequently used in practice is to average samples of the total resources in use, taken at uniformly spaced points in time over the read-out period. Another alternative, only valid if the job holding time is much smaller than the read-out period, is to measure job arrivals, number of needed resources per job and holding time per job. Under these conditions let $N(t_1,t_2)$ denote the number of job arrivals over the time interval (t_1,t_2). Then (2) can be rewritten as:

$$\begin{aligned} A(t_1,t_2) &= \left[N(t_1,t_2)\,/\,(t_2 - t_1)\right]\cdot\left[W(t_1,t_2)\,/\,N(t_1,t_2)\right] \\ &= \lambda(t_1,t_2)\cdot n(t_1,t_2)\cdot h(t_1,t_2) \end{aligned} \tag{3}$$

In this form $A(t_1,t_2)$ has the form of (1) where it is expressed as the product of an average measured job arrival rate, $\lambda(t_1,t_2)$, an average number of resources used per job, $n(t_1,t_2)$, and an average measured holding time per job, $h(t_1,t_2)$.

5.5 Convergence of the measured traffic intensity and choice of read-out period

The measured traffic intensity, $A(t_1,t_2)$, given in (2) and, when applicable, in (3), is an estimate of the average traffic intensity A, and as $(t_2 - t_1)$ increases, $A(t_1,t_2)$ converges to A. From a traffic measurement perspective, it is desired to choose a read-out period length $(t_2 - t_1)$ large enough that $A(t_1,t_2)$ lies within a narrow confidence interval about A. However, the read-out period cannot be chosen too large, for then the traffic intensity process will no longer be approximately stationary, and

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[2] This Recommendation defines normal and high load traffic intensities (see 6.3) for read-out periods satisfying Assumption 1, and it provides methods for determining traffic intensities for dimensioning (see clause 7) to meet specified GOS parameters during those periods. Dimensioning might also be done to meet other GOS parameters during read-out periods violating Assumption 1. Traffic intensity measurements and methods for those periods are outside the scope of this Recommendation.

[3] When holding times are much smaller than the read-out period, an alternative definition is to use the total work that arrives over the interval (t_1, t_2). In some cases it is easier to measure the total work a job brings when it arrives rather than measuring the actual resource usage (e.g. for packet networks one can accumulate the total octets that arrive as opposed to measuring the total octets sent).

the measured traffic intensity looses its ability to characterize load levels for dimensioning resources and monitoring GOS.

If a read-out period length cannot be determined that gives an acceptable confidence interval and satisfies Assumption 1 of 5.3, then more detailed models should be considered. If a satisfactory model cannot be found, then the methods in this Recommendation should not be used.

The required length of the read-out period to achieve a desired size confidence interval depends on the traffic model that approximates the actual traffic. For example, consider a circuit group to which calls arrive as a Poisson process with a known average holding time, h, and an unknown average arrival rate, λ. To estimate the average traffic intensity (i.e. λh), it is necessary to take measurements over a read-out period that is long enough to obtain a desired level of confidence. Suppose it is desired to estimate the traffic intensity with a 95% confidence interval width smaller than $\alpha \times$ *(estimated traffic intensity)*. Then it can be shown, based on well known results for the Poisson processes, that the measurement interval must be long enough to observe more than $[2\times 1.96/\alpha]^2$ call arrivals (e.g. if $\alpha = 0.2$, the read-out period must be long enough to observe more than 384 call arrivals). Methods to choose a read-out period length for other types of traffic models should be based, when possible, on appropriate statistical models to approximate the confidence interval, and read-out periods should be chosen long enough to achieve a desired level of confidence based on the statistical model. If appropriate statistical models are not available, statistical techniques based on the analysis of the measured traffic intensity may be possible. For example, the average measured traffic intensity as defined in (2) can be examined as $(t_2 - t_1)$ increases, and criteria based on the convergence of this average measured traffic intensity can be used.

For certain types of actual traffic patterns (e.g. very bursty traffic), some traffic models can lead to very short read-out periods. In these cases alternative models should be used, if possible, that lead to longer read-out periods (e.g. greater than 5 minutes) so that resources are not dimensioned for infrequent small interval peak traffic levels.

6 Measurement methods and normal and high load traffic intensities

The read-out period is chosen so that the arrival process is close to a stationary model; but looking over many read-out periods, the traffic intensity will change significantly. The telecommunications resources must be dimensioned to accommodate the higher load levels that will occur over time. The notions of normal and high load conditions are used to identify the traffic intensity values to use for resource dimensioning.

The *normal* load condition is intended to represent frequent busy operating conditions of the network for which user service expectations should be met. A *high* load condition is intended to represent less frequently encountered operating conditions for which user service expectations would not necessarily be met, but for which the level of performance achieved should be high enough to avoid significant user dissatisfaction, spread of congestion (e.g. due to excessive user repeat attempts), etc.

6.1 Daily measurement methods

The recommended daily traffic intensity measurement method is the one developed in Recommendation E.492, and it will be termed the Daily Peak Period (DPP) method. In this method, the traffic intensity is measured for consecutive read-out periods of each day and the peak traffic intensity for the day is recorded. This method requires continuous measurement.

If the traffic patterns are known to be somewhat predictable, non-continuous measurement methods are possible. If it is known that peak period loads will usually occur during certain intervals of the day, a Fixed Daily Measurement Interval (FDMI) method can be used in which a predetermined time interval (i.e. a set of consecutive read-out periods) is identified. During this time interval each day traffic intensity measurements are taken. The peak traffic intensity over the measured read-out periods is recorded for the day.

If it is known that peak period loads will likely occur during a particular read-out period during the day, the FDMI method can be reduced to measuring traffic intensity only during the identified busy read-out period and recorded for the day.

For the non-continuous measurement method (i.e. FDMI), it is necessary to periodically take additional measurements to make sure traffic patterns have not changed and the busy periods are still being captured during the measurement intervals being used.

In some cases tariff structures may change during the day to stimulate (or curtail) traffic, and the desired GOS from the network may be different for the different tariff structures. In the cases when the GOS parameters change, the chosen traffic measurement method should be used for each time interval a particular set of GOS parameters apply. This is because the network must be dimensioned to handle the load for each of these time periods. Thus, a daily peak traffic intensity should be recorded for each GOS period during the day.

6.2 Grouping of daily measurements

In order to do meaningful statistical analysis of traffic intensity measurements, the daily measurements have been traditionally organized into statistically homogeneous groups (i.e. collected into daily groups having, approximately, the same statistical behaviour). The three daily groups to be considered are: working days, week-end days (including most holidays), and yearly exceptional days (e.g. Christmas, Mother's Day, extraordinary events, etc.). If GOS objectives change during the day due to tariff strategies or other reasons, as discussed above, the groupings would be expanded to be by day and by GOS period.

Week-end traffic intensities are usually smaller than the working days intensities. Thus week-end days have been traditionally excluded to determine normal and high traffic loads. However, the method proposed below for determining normal and high loads does not need to previously exclude the week-end days because, if they really have lower traffic intensity, they will be automatically excluded by the method itself.

This is not the case of the yearly exceptional days. Different GOS objectives are typically used by the operators for those days than for either normal load or high load GOS. These days of exceptional high traffic are not automatically excluded by the method for determining normal and high loads.

Thus, if different GOS objectives are used for those days, they should be excluded before determining normal and high loads. Note that the ITU-T Recommendations do not address GOS target values for yearly exceptional days, so operators need to agree on a bilateral basis to what GOS objectives should be met for those days.

Although working and week-end days do not have to be distinguished for determining normal and high loads, it may be necessary to distinguish them if additional statistical analysis is desired.

6.3 Normal and high load traffic intensities

Using either of the daily measurement methods described above (DPP or FDMI), a daily peak traffic intensity for a traffic system is determined. This daily peak traffic intensity measurement is the basis for determining normal and high load traffic intensities. If there are multiple GOS periods during the day, as discussed above, a daily peak traffic intensity would be determined for each GOS period and normal and high load traffic intensities would be found for each daily GOS period. The following definitions of normal and high load traffic intensities for a traffic system are based on the methods developed in Recommendation E.492.

Normal and high load traffic intensities are defined over a monthly time interval.[4] A set of days is chosen out of the month. This set of days may be either all the days except the yearly exceptional ones, or only the group of working days. This second option may be used only when it is known that the traffic intensities in the week-end days are smaller than in the working days.

The *normal load traffic intensity* for a traffic system is determined by the following steps:

1) Order the chosen days from lowest to highest daily peak traffic intensity measurement.

2) Select the day having the fourth highest daily peak traffic intensity measurement. This traffic intensity is defined as the *normal load traffic intensity* of the traffic system for the month being considered.[5]

The *high load traffic intensity* for the traffic system is determined by following the procedure indicated in step 1) above and then selecting the day having the second highest daily peak traffic intensity measurement. This traffic intensity is defined as the *high load traffic intensity* of the traffic system for the month being considered.

It is important to note that within a telecommunications network there are different traffic systems and their normal and high loads must be determined individually. In fact, the daily peak traffic intensity for different traffic systems can occur during different read-out periods. For example, consider a single exchange for which there are three major traffic systems: circuit groups, call processing and signalling network. Suppose in one hour the average call arrival rate is 100 calls/s with an average call holding time of 180 s, and in another hour the average call arrival rate is 200 calls/s with a 60 s average call holding time. For the circuit group traffic system, the first hour has the highest traffic intensity (18 000 erlangs). For the call processing and signalling traffic systems, the second hour has the higher traffic intensity (assuming the holding time per call in those systems is the same for both hours).

6.4 Considerations on service measurements

In case the traffic is composed of jobs that correspond to different services (multiservice traffic) with different traffic characteristics or different potential demand growth, it can be useful to make individual measurements for the traffic of each service. In case some services have a potential demand growth greater than other services, the period determining the normal or high load of those services could correspond in the future to the period determining the normal or high load of the aggregated traffic. Thus, attention should not only be paid to the measurements in the periods of normal or high load of the aggregated traffic, but also to the measurements in the periods of high traffic of services which, due to its present volume and to their potential growth, could determine the future normal and high loads of the aggregated traffic. Measurements to provide the daily traffic profile for each service could be useful to identify those periods to which attention must also be paid. This subject requires further study.

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[4] A month is chosen because it is short enough that seasonal variations and growth will not significantly affect load behaviour during the time interval considered, and it is long enough to get adequate statistical significance.

[5] If there is more information available on the distribution of the peak daily traffic load, a day other than the fourth highest might be determined to be more appropriate.

7 Determination of the traffic intensity values for resource dimensioning

Resources in a traffic system are dimensioned to meet specified GOS objectives for defined load periods. In this clause the normal and high load traffic intensities defined above are considered, and methods for determining traffic intensities for dimensioning resources to meet GOS objectives are described.

Given the way normal and high load traffic intensities are defined, they must be viewed as observations of random variables. That is, the measured values of normal and high load traffic intensities for each month are samples from their respective probability distribution.

Ideally, the objective of resource dimensioning in a traffic system is to dimension the resources so that the normal and high load GOS parameters are met when the normal and high load traffic intensities occur, respectively, in each month. The problem in meeting this ideal objective is that the normal and high load traffic intensities for each month are random variables, and to dimension so these objectives are met with certainty for each month could be very costly. An alternative might be to dimension so as to keep the probability of not meeting the normal and high load GOS objectives in any month less than some chosen value. However, this approach requires knowledge of, or good approximations for, the probability distribution functions of the normal and high load traffic intensities random variables. In general, such distribution information is difficult to obtain due to the lack of homogeneity in traffic patterns from month-to-month. This lack of homogeneity results in small samples on which to base statistical analysis, and therefore large confidence intervals would result. It has been found from analysis and simulation that the probability distributions for normal and high load traffic intensities are very sensitive to the underlying traffic intensity distribution functions, and therefore it is not possible to give a general methodology along these lines.

As an alternative to basing dimensioning on knowledge of the probability distribution functions of the normal and high load traffic intensity random variables, the following method based on an observed Yearly Representative Value (YRV) is suggested. In this method, the normal and high load traffic intensities are recorded for each month of a year. The YRV of the normal (high) load for that year is chosen to be either the second highest or the highest observed normal (high) load traffic intensity for that year. If the traffic intensity tends to be fairly homogeneous from month-to-month, it is recommended that the second highest value be chosen, since this would help avoid outliers. However, if there is not much homogeneity (e.g. one or two months tend to generate the peak loads), then using the peak value is recommended.

If the normal or high load YRV comes from a situation in which there was significant blocking in the network, it is necessary to estimate the offered traffic intensity and use it for the YRV rather than the measured carried traffic intensity. Recommendation E.501 provides some methods for estimating offered traffic intensity from measured traffic intensity in a circuit switched network.

Once the normal and high load YRVs for the current year have been determined, the normal and high load traffic intensities to use to dimension the traffic system for future years are obtained by applying the expected growth to the YRVs for the current year. The expected growth should be determined using traffic forecasting methods (see Recommendations E.506, E.507 and E.508). The growth model applied to the YRV could also include some safety margin to account for uncertainty. The amount of safety margin to use must be determined by experience with the specific traffic system and the circumstances in which it is being dimensioned.

8 History

Recommendation E.500 – First issue 1969; revised in 1992; present revision in 1998.

ANNEX A

Example of stationary traffic intensity with holding times larger than the read-out period

This annex illustrates how traffic systems with call holding times greater than the read-out period can lead to a traffic intensity process over the read-out period that can be approximated by a stationary process, but equation (1) is not valid for computing average traffic intensity over the read-out period.

Consider a traffic system consisting of a circuit group with two call arrival processes. The first call arrival process, Process 1, has calls with exponentially distributed holding times, an average holding time of 1 minute, and a stationary Poisson call arrival process with an average call arrival rate of 100 calls/minute for all time. The second call arrival process, Process 2, has a deterministic call holding time of 100 minutes, and a deterministic call arrival process that has a call arrival rate of 20 calls/min for time, t, in the interval $0 < t < 10$ min, and 0 calls/min for all other times[6].

Figure A.1 illustrates the resulting traffic intensities. Process 1 is a stationary process, and equation (1) can be used to determine its average traffic intensity for all time t as 100 circuits. Process 2 is a non-stationary process, so its average traffic intensity depends on the length and placement of the time interval over which the average is taken. However, its instantaneous traffic intensity is easily characterized; it is seen to increase linearly over the time interval (0, 10) min, stay constant at 200 circuits over the interval (10, 100) min, and drop linearly back to zero over the interval (100, 110) min.

The total traffic intensity on the system can be characterized by the sum of the average traffic intensity of Process 1 and the instantaneous traffic intensity of Process 2, as shown in Figure A.1. For time intervals $(-\infty, 0)$, (10, 100), and $(110, \infty)$ the traffic intensity process can be approximated by a stationary process. For time intervals $(-\infty, 0)$ and $(110, \infty)$ the approximating process is just Process 1, and for time interval (10, 100) the approximating process is Process 1 applied on top of 200 occupied circuits. It is clear that equation (1) is not valid during time interval (10, 100).

[6] The choice of deterministic arrivals and holding times for Process 2 is only for ease of explanation. It is straightforward to expand this example to include more realistic models that include randomness in Process 2. Process 2 is intended to represent such services as video on demand, with long holding times (about 90 minutes) and most call arrivals concentrated in certain time intervals (typically between 8 PM and 9 PM).

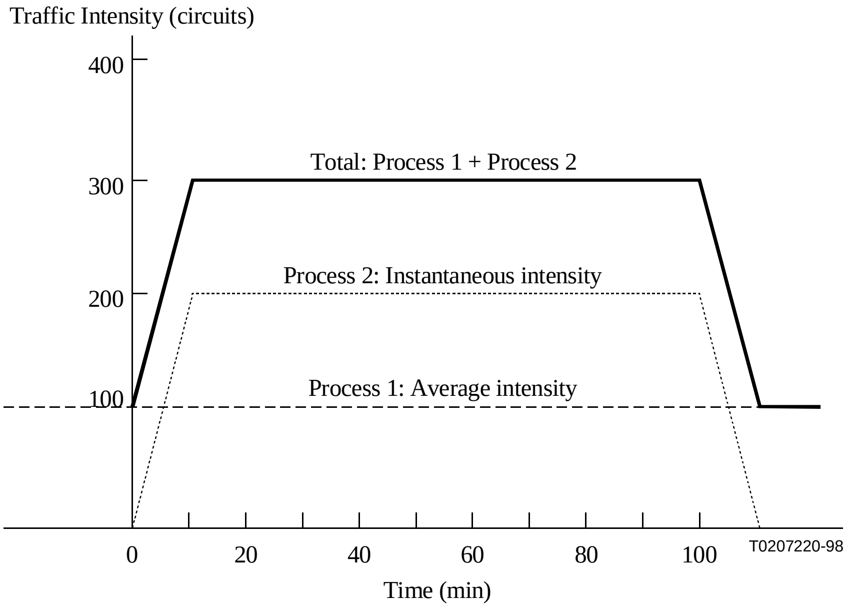

Figure A.1/E.500

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