E4.05
SO7

IMPERIAL COLLEGE LONDON

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
EXAMINATIONS 2003

MSc and EEE PART IV: M.Eng. and ACGI

TRAFFIC THEORY & QUEUEING SYSTEMS

Monday, 19 May 10:00 am

Time allowed: 3:00 hours

There are FIVE questions on this paper.

Answer FOUR questions.

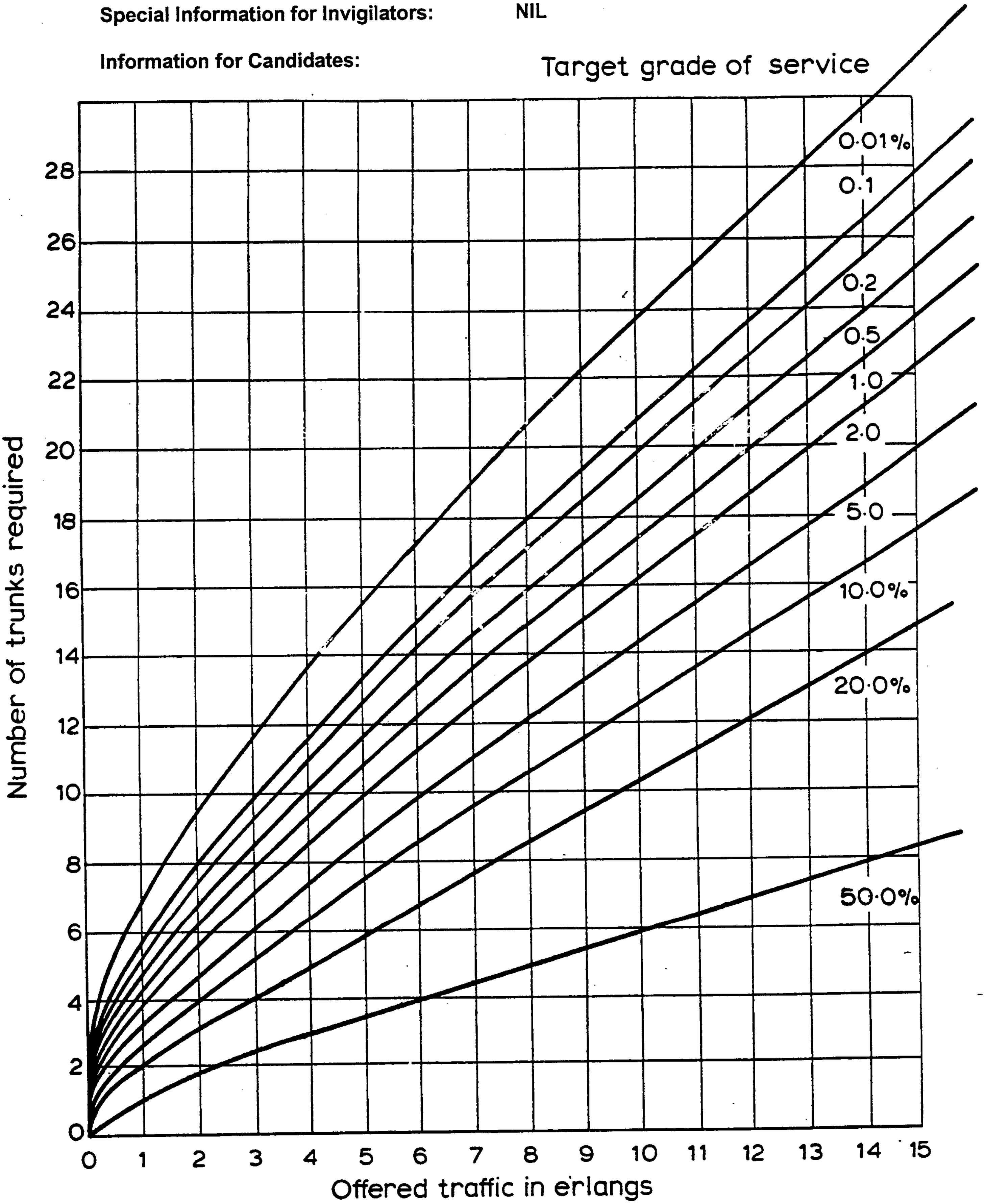
Corrected Copy

Any special instructions for invigilators and information for candidates are on page 1.

Examiners responsible First Marker(s) : J.A. Barria
Second Marker(s) : P. De Wilde

Special Information for Invigilators: NIL

Information for Candidates:



Traffic capacity on basis of Erlang B formula.

1. (a) State and discuss the validity of the underlying assumptions of the Erlang model for the traffic carried by an unbuffered multi-channel link. [5]

(b) For the Engset model, write down (i) the global balance equations and (ii) the local balance equations and clearly state the corresponding birth/death coefficients. [5]

(c) Eight Erlangs of pure chance traffic (Poisson arrival streams and exponential holding times) is offered to a 12-channel communication link. Estimate:

(i) The mean of the carried traffic,

(ii) The mean channel occupancy, and

(iii) The proportion of time for which the link is completely idle (no channel busy).

[10]

2. (a) A communication link consists of a first-choice group of channels of size M which is fed with a Poisson stream of demands with rate λ and a second-choice group of channels of size N. Traffic is only offered to the second-choice group when the first-choice group is saturated. If the channel holding times are exponential with a mean service rate per channel of μ,

(i) Draw the state transition diagram of a Markov model for the traffic pattern on this 2-group link. [3]

(ii) Discuss the validity of Local and Global balance equations. [3]

(iii) Briefly discuss how you would solve the call blocking probability for the overflow link? [4]

(b) In a call centre enquiry system incoming calls are placed in a queue which is served by a FIFO queue discipline by a group of 10 operators. Assuming that the incoming traffic intensity is 8 Erlangs, determine:

(i) The probability that an incoming call will be delayed (assume no loss of calls), [5]

(ii) The probability that an incoming call will be blocked if the buffer size is five (5) calls only. [5]

3. (a) A buffered system is being offered a pure chance traffic (Poisson arrival stream and exponential service time). The system is composed of K servers and it can be assumed that posseses an infinite buffer size for incoming calls.

If the system is operating with a FIFO queue discipline, what can be said about:

(i) The waiting-time distribution for arrival that find all K servers busy?

(ii) The queue-length distribution for delayed arrivals?

[14]

(b) Mathematically formulate an equivalent representation of the Generic Rate Algorithm (in relation to the UPC (user parameter control) technique proposed by the ATM Forum). Discuss any underlying assumption made.

[6]

4. (a) Discuss the importance of Admission Control in Broadband Networks. Discuss the relevance of the Equivalent capacity functions. [6]

(b) A Poisson stream of messages with rate λ = 18000 messages/minute is fed into a 64 Kbits/seconds single-channel communication link. Assume that no message is lost and if the system is busy the messages can be placed in a buffer.

The message stream consists of a random mixture of 1-packet messages and 2-packet messages. The system gives non-pre-emptive priority to 1-packet messages.

Assuming that each packet is of length B = 160 bits and that ¾ of the messages are 1-packet messages determine:

(i) The mean waiting time for 1-packet message,

(ii) The mean waiting time for 2-packet messages, and

(iii) The overall mean message waiting time.

[14]

5. (a) Using a two-state voice source model represented in Figure 5.1, derive a composite N-voice traffic source model.

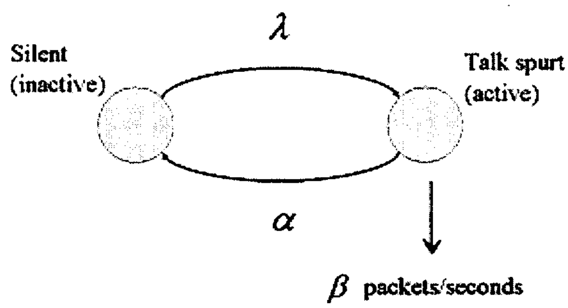


Figure 5.1

(i) Derive the probability that the *N*-voice source has *i* sources active. [2]

(ii) Derive the state space representation (or Markov chain) of a voice multiplexer with buffer capacity N. [2]

(iii) Assume that the service time distribution of a packet is exponentially distributed with mean = *1/v* seconds.

- Obtain the average number of packets entering the system

- Obtain the system utilisation

[4]

(b) Assume the following characteristics of a two-processor degradable system:

- One processor failure rate: $\gamma = 0.2$ [failures/unit_time],
- One processor repair rate: $\tau = 4.0$ [repairs/unit _time],
- One processor replacement: $\rho = 8.0$ [replacements/unit_time].

Assume a coverage factor of c = 0.99.

Assume also that a job can be divided into parallel subtasks, and that

- The service rate when one processor is operational is $R_I = 1.0$ [service/unit_time],
- The service rate when two processors are operational is $R_{II} = 1.6$ [service/unit_time].

(i) Define the state space of the system and its associated Markov chain. [6]

(ii) Find the value of $\lim_{t \to \infty} E[W(t)]$, where $W(t) \equiv Y(t)/t$ and *Y(t)* is the accumulated reward per unit of time *t*. [6]