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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.

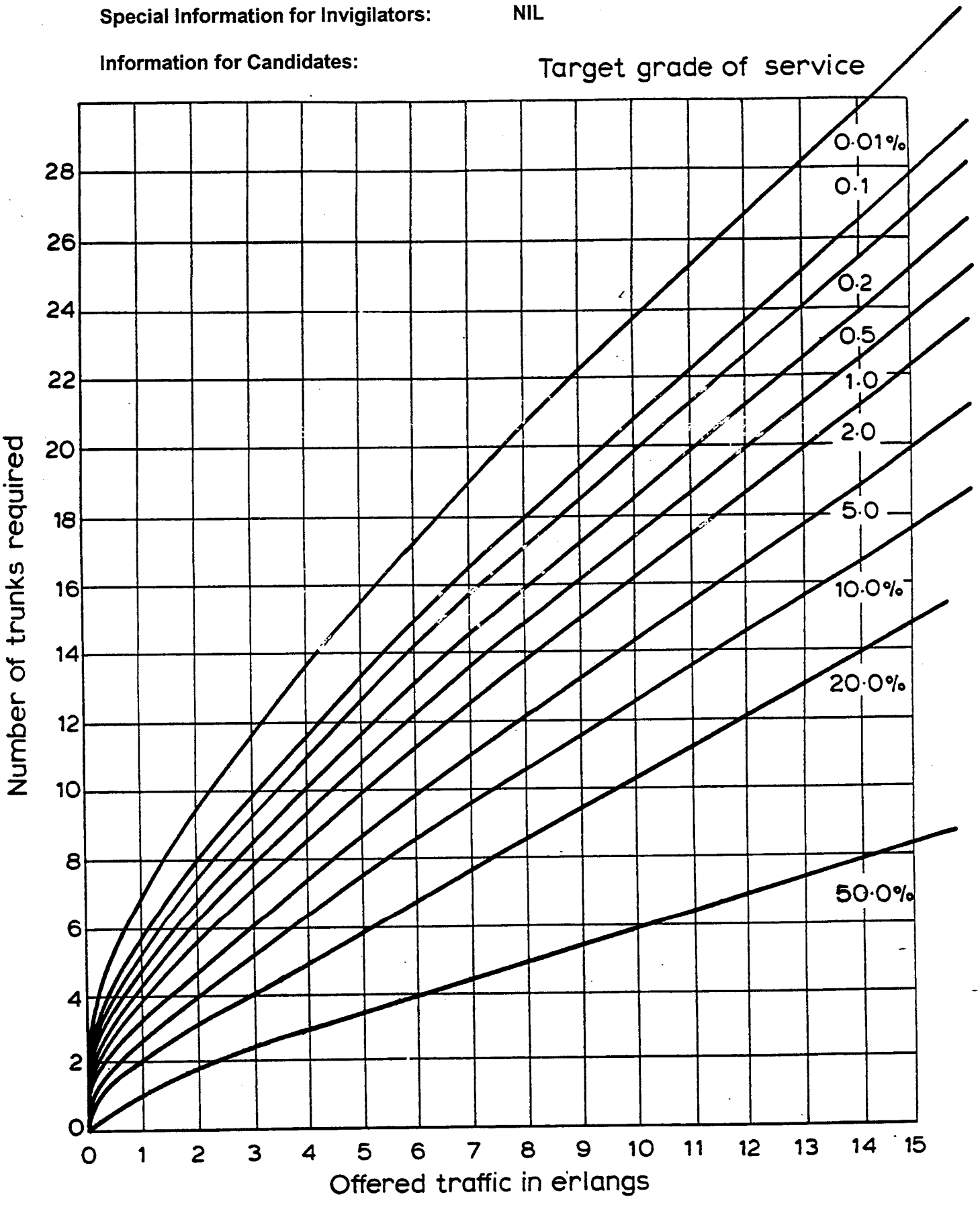
Corrected Copy

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.

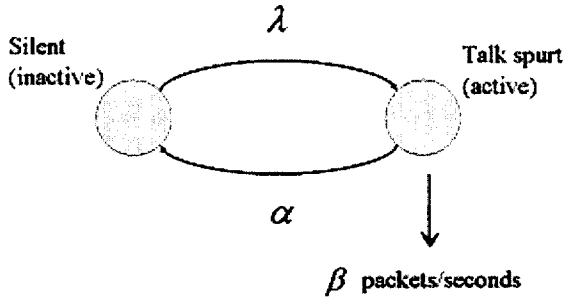


Figure 5.1

(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]