TKK HELSINKI UNIVERSITY OF TECHNOLOGY **Demonstrations**
Department of Communications and Networking **Lecture 3**
S-38.1145 Introduction to Teletraffic Theory, Spring 2008 24.1.2008

D3/1 Consider telephone traffic carried by a 5-channel link in the telephone network. Use the pure loss system model. New calls arrive according to a Poisson process at rate 2 calls/min, and call holding times are independently and identically distributed with mean 3 min. Determine the following traffic intensities:

(a) the traffic offered,

(b) the traffic carried, and

(c) the traffic lost.

D3/2 Consider the processor of a packet router in a packet switched data network. Traffic consists of data packets to be processed. Use the pure waiting system model with a single server. New packets arrive according to a Poisson process at rate 2 packets/ms, and packet processing times are independently and exponentially distributed with mean 0.4 ms.

(a) What is the traffic load?

(b) What is the probability that an arriving packet will be processed immediately after the arrival (without any waiting)?

(c) What is the probability that a packet has to wait longer than 2 ms?

D3/3 Consider elastic data traffic carried by a 100 Mbps link in a packet switched data network. Use the pure sharing system model with a single server. New flows arrive according to a Poisson process at rate 6 flows/s, and the average size of the files to be transferred is 15 Mb. Determine

(a) the traffic load,

(b) the throughput of a flow, and

(c) the average file transfer time.

D3/4 Consider telephone traffic carried by a link in a packet switched data network. A single call is modelled as a streaming CBR flow with a fixed transmission rate of 64 kbps. The link speed is $5 * 64$ kbps. Use the infinite system model. New calls arrive according to a Poisson process at rate 2 calls/min, and the average flow duration is 3 minutes. Determine

(a) the traffic offered,

(b) the traffic carried, and

(c) the loss ratio.

D3/1 The model is a pure loss system of type M/G/n/n with $n = 5$ (L3/4,10). Since $\lambda = 2$ calls/min and $h = 3$ min, the traffic intensity (L3/6) is

$$a = \lambda h = 2 \cdot 3 = 6 \text{ erl}$$

and the call blocking probability (L3/11)

$$B_{\mathrm{C}} = \mathrm{Erl}(n, a) = \mathrm{Erl}(5, 6) = \frac{\frac{6^5}{120}}{1 + 6 + \frac{6^2}{2} + \frac{6^3}{6} + \frac{6^4}{24} + \frac{6^5}{120}} \overset{\text{num.}}{=} 0.36$$

(a) The traffic offered (L3/9):

$$a_{\text{offered}} = a = 6 \text{ erl}$$

(b) The traffic carried (L3/9):

$$a_{\text{carried}} = a(1 - B_{\mathrm{C}}) = 6 \cdot (1 - 0.36) = 3.84 \text{ erl}$$

(c) The traffic lost (L3/9):

$$a_{\text{lost}} = aB_{\mathrm{C}} = 6 \cdot 0.36 = 2.16 \text{ erl}$$

D3/2 The model is a pure single server queueing system of type M/M/1 (L3/18,23) with parameters $\lambda = 2$ packets/ms and $1/\mu = 0.4$ ms. Thus, the probability that a packet has to wait longer than z ms is (L3/24)

$$P_z = \rho e^{-\mu(1-\rho)z},$$

where $\rho = \lambda/\mu$ is the system load. Note, in particular, that $P_0 = \rho$.

(a) The system load (L3/20):

$$\rho = \frac{\lambda}{\mu} = 2 \cdot 0.4 = 0.8$$

(b) The probability that an arriving packet will be processed immediately after the arrival (without any waiting) is (L3/24):

$$P\{\text{“no waiting”}\} = 1 - P_0 = 1 - \rho = 1 - 0.8 = 0.2$$

(c) the probability that a packet has to wait longer than 2 ms is (L3/24):

$$P\{\text{“waiting longer than 2 ms”}\} = P_2 = \rho e^{-\mu(1-\rho)2} = 0.8 \cdot e^{-1.0} \overset{\text{num.}}{=} 0.29$$

D3/3 The model is the pure single server sharing system of type M/G/1-PS (L3/31,36) with parameters $\lambda = 6$ flows/s, $S = 15$ Mb, and $C = 100$ Mbps. The average file transfer time with full rate C is thus $1/\mu = S/C = 15/100 = 0.15$ s.

(a) The traffic load (L3/33):

$$\rho = \frac{\lambda}{\mu} = 6 \cdot 0.15 = 0.90$$

(b) The throughput of a flow (L3/37):

$$\theta = C(1 - \rho) = 100 \cdot (1 - 0.9) = 10.0 \text{ Mbps}$$

(c) The average file transfer time (L3/35):

$$D = \frac{S}{\theta} = \frac{15}{10} = 1.5 \text{ s}$$

D3/4 The model is the infinite system of type M/G/∞ (L3/44,48) with with the same parameters as in (a), $\lambda = 2$ calls/min and $h = 3$ min. The link capacity is $C = 5 \cdot 64$ kbps, and the bit rate of a single CBR flow $r = 64$ kbps. Thus, $n = C/r = 5$.

(a) The traffic offered (in erlangs)

$$a_{\text{offered}} = a = \lambda h = 2 \cdot 3 = 6 \text{ erl}$$

and as a bit rate (L3/46):

$$R_{\text{offered}} = R = ar = 6 \cdot 64 = 384 \text{ kbps}$$

(b) Let us utilize the loss ratio (determined below in (c)) to find out the traffic lost as a bit rate:

$$R_{\text{loss}} = p_{\text{loss}} R_{\text{offered}} = 0.25 \cdot 384 = 96 \text{ kbps.}$$

The traffic carried (as a bit rate) is thus

$$R_{\text{carried}} = R_{\text{offered}} - R_{\text{loss}} = 384 - 96 = 288 \text{ kbps}$$

(c) The loss ratio (L3/49):

$$p_{\text{loss}} = \text{LR}(n, a) = \text{LR}(5, 6) = \frac{1}{6} \sum_{i=6}^{\infty} (i - 5) \frac{6^i}{i!} e^{-6} \overset{\text{num.}}{=} 0.25$$

(The infinite sum is approximated by a finite sum with about 20 terms, which gives a sufficient accuracy.)