City University of Hong Kong
Department of Electrical Engineering

EE3009 Data Communications and Networking

Solution to Tutorial 1

1.

a. When circuit switching is used, at most 20 circuit-switched users can be supported. This is because each circuit-switched user must be allocated 10 Mbps bandwidth, and there is 200 Mbps of link capacity that can be allocated.

b. No. Under circuit switching, those 39 users would each need to be allocated 10 Mbps, for an aggregate of 390 Mbps - more than the 200 Mbps of link capacity available.

c. The probability that a given (*specific*) user is busy transmitting, which we'll denote p, is just the fraction of time it is transmitting, i.e., 0.3. The probability that one specific other user is not busy is $(1-p)$, and so the probability that *all* of the other $N_{ps}-1$ users are not transmitting is $(1-p)^{N_{ps}-1}$. Thus the probability that one specific user is transmitting and the remaining users are not transmitting is $p(1-p)^{N_{ps}-1}$, which has the numerical value of 3.8980E-7.

d. The probability that exactly one (*any* one) of the N_{ps} users is busy is N_{ps} times the probability that a given specific user is transmitting and the remaining users are not transmitting (the answer to (c) above), since the one transmitting user can be any one of the N_{ps} users. Thus, it is given by $N_{ps}p(1-p)^{N_{ps}-1}$, which has the numerical value of 1.5202E-5. This user will be transmitting at a rate of 10 Mbps over the 200 Mbps link, using a fraction 0.05 of the link's capacity when busy.

e. The probability that 20 specific users of the total 39 users are transmitting and the other 19 users are idle is $p^{20}(1-p)^{19}$. Thus the probability that *any* 20 of the 39 users are busy is $\binom{39}{20}p^{20}(1-p)^{19}$, where $\binom{39}{20}$ is the coefficient of the binomial distribution. The numerical value of this probability is 2.7393E-3.

f. The probability that more than 20 users of the total 39 users are transmitting is $\sum_{i=21}^{39}\binom{39}{i}p^{i}(1-p)^{39-i}$. The numerical value of this probability is 1.5975E-3. Note that 20 is the maximum number of users that can be supported using circuit switching (the answer to part (a)). With packet switching, nearly twice as many users (39) are supported with a small probability that more than 20 of these packet-switching users are busy at the same time.

2.

a. d_{prop} $=m/s$ seconds.
b. $d_{trans}= L/R$ seconds.
c. end-to-end delay = $(m/s + L/R)$ seconds.
d. The last bit of the packet has just left Host A.
e. The first bit of the packet is in the transmission link, but has not reached Host B.
f. The first bit of the packet has reached Host B.
g. $m/s = L/R$, thus

$$m = \frac{L}{R}s = \frac{120}{56 \times 10^3}\left(2.5 \times 10^8\right) = 536\,\text{km}.$$

3. Source port number 61 and destination port number 37.

4. IP telephony and IP video calls generate time-sensitive traffic, which cannot be delayed by congestion control mechanisms. Also, they can tolerate some packet loss. Thus, UDP is more suitable.

5. Yes, both segments will be directed to the same socket. For each received segment, at the socket interface, the operating system will provide the process with the IP addresses to determine the origins of the individual segments.