City University of Hong Kong
Department of Electrical Engineering

EE3009 Data Communications and Networking

Solution to Tutorial 5

1.

$$E[t_{SW}] = t_0 + \sum_{i=1}^{\infty}(i-1)t_{out}P_f^{i-1}(1-P_f)$$

$$= t_0 + t_{out}(1-P_f)\sum_{i=1}^{\infty}(i-1)P_f^{i-1}$$

Using the identity $\sum_{i=0}^{\infty} x^i = \frac{1}{1-x}$

Differentiate both side with respect to *x*, we have $\sum_{i=0}^{\infty} ix^{i-1} = \frac{1}{(1-x)^2}$

Hence, $x\sum_{i=0}^{\infty} ix^{i-1} = \sum_{i=0}^{\infty} ix^i = \frac{x}{(1-x)^2}$

Therefore, $E[t_{SW}] = t_0 + t_{out}(1-P_f)\frac{P_f}{(1-P_f)^2} = t_0 + \frac{t_{out}P_f}{1-P_f}$

Alternatively,

$$E[t_{SW}] = t_0 + \sum_{i=1}^{\infty}(i-1)t_{out}P_f^{i-1}(1-P_f)$$

$$= t_0 + t_{out}\sum_{i=1}^{\infty}(i-1)P_f^{i-1}(1-P_f)$$

$$= t_0 + t_{out}[P_f(1-P_f) + 2P_f^2(1-P_f) + 3P_f^3(1-P_f) + ...]$$

$$= t_0 + t_{out}[P_f - P_f^2 + 2P_f^2 - 2P_f^3 + 3P_f^3 + ...]$$

$$= t_0 + t_{out}[P_f + P_f^2 + P_f^3 + ...]$$

$$= t_0 + \frac{t_{out}P_f}{1-P_f}$$

2.

i) First, we have the following:

$n_f = 256 \times 8 = 2048$

$$P_f = 1-(1-10^{-4})^{n_f} = 0.1852$$

$t_{prop} = 100\text{ ms}$

Using the results for Stop-and-Wait,

$$\eta = (1 - P_f)\frac{1 - \frac{n_0}{n_f}}{1 + \frac{n_a}{n_f} + \frac{2(t_{prop} + t_{proc})}{n_f}R}$$

=0.126.

ii) The same parameters as in (i) are used.
For the window size, $W_s \le 2^3$-1 = 7, and at the same time,

$W_s = \frac{2 \times R \times d}{n_f} + 1$, where d is the one one-way propagation delay

$$W_s = \frac{56 \times 10^3 \times 2 \times 100 \times 10^{-3}}{2048} + 1 = 6.468$$

So, the maximum number of complete frames allowed by W_s is 6
Considering the two constraints, W_s=6 is suitable.

Using $\eta = (1 - P_f)\frac{1 - \frac{n_0}{n_f}}{1 + (W_s - 1)P_f}$

$$\eta = \frac{1 - 0.1852}{1 + 5 \times 0.1852} = \frac{0.8148}{1.926} = 0.423$$