# 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 $\sum_{i=0}^{\infty}x^i = \dfrac{1}{1-x}$

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

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

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

Alternatively,

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

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

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

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

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

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

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,

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

=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,

$W_s = \dfrac{2 \times R \times d}{n_f} + 1$, 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 $\eta = (1 - P_f) \dfrac{1 - \dfrac{n_0}{n_f}}{1 + (W_s - 1)P_f}$

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