

ECE - Computer Networks II

Winter 2007

Problem Set #2

1. *Textbook Problem #4.4.*

An arrival process A has envelope E_1 and is passed through a regulator with subadditive envelope E_2 (with $E_2(0) = 0$).

- (a) Show that $D = A * E_2$ has envelope $E_1 * E_2$.
- (b) If E_1 is also subadditive (with $E_1(0) = 0$), then show that $E_1 * E_2$ is also subadditive with (with $E_1 * E_2(0) = 0$).

2. *Textbook: KMK, Problem #4.9.*

- (a) $A(t)$ is a leaky bucket controlled fluid source with $\alpha(t) = \sigma + \rho \cdot t$ that passes through a system with maximum delay d_{max} . Show that the output $B(t)$ is constrained by $\alpha^*(t) = (\sigma + \rho \cdot d_{max}) + \rho \cdot t$.
- (b) $A(t)$ is controlled with $\alpha(t) = \sigma + \rho \cdot t$, and the server has an infinite buffer. derive a constraint for the backlog.

3. Consider N_1 dual leaky bucket (R_1, σ_1, ρ_1) flows multiplexed with N_2 leaky bucket (σ_2, ρ_2) flows at a link with capacity C . Derive an expression for the maximum delay d_{max} in a FCFS server.

4. Consider a non-work-conserving FCFS server that takes vacations every other T seconds, i.e., for T seconds, the server services traffic in FCFS order at rate C , and for the next T seconds, the server services no traffic, even if traffic is queued.

- (a) What is the lower service curve of this server.
- (b) Derive an expression for the maximum delay d_{max} for N (σ, ρ) flows multiplexed at this server. Justify your answer with a graphical illustration.

5. Consider time to be slotted to one second and consider a fluid source that transmits a sequence $\{2, 5, 1, 3, 2, 5, 1, 3, \dots\}$. This means that, for example, the source transmits fluid at rate 2 (bits per second) in the intervals $\{[0, 1], [4, 5], \dots\}$.
- (a) Sketch the empirical envelope $\mathcal{E}(t)$ for this source as well as the cumulative arrivals $A(t)$ of the original stream.
 - (b) Determine a valid set of (R, σ, ρ) traffic parameters with a value of σ greater than 0. Sketch the resulting envelope $E(t)$ along with the empirical envelope $\mathcal{E}(t)$. Make sure your parameters are tight, i.e., $(10^6, 10^6, 10^6)$ will not be given credit.
 - (c) For a link capacity $C = 3$ and the above (R, σ, ρ) flow, compute the maximum queueing delay.