# 15-441:Networking – Homework 4

Spring 2006

**Out: Friday 4/28/06 - Due: Friday 5/5/06, 5pm**

**Submission is electronic, similar to previous homeworks**

**Please observe that late days will not be available, as we will release solutions Friday for exam-study purposes.**

## Problem 1: TCP throughput

Chapter 6, question 16

## Problem 2: TCP congestion control

Chapter 6, question 28

## Problem 3: Multimedia problem

Chapter 9, problem 33

## Problem 4: Security problem

Part A: Consider slides 20 and 21 of lecture 24. Based on the belief rules summarized on slide 20, summarize which beliefs B has after receiving each of the packets sent to it in the protocol described on slide 21. Provide a brief argument for each belief B acquires. Your argument may refer to beliefs B had before the beginning of the protocol if you wish. There is no need to provide a justification for beliefs such as "S has not been taken over by an attacker."

Part B: Alice claims that the protocol provides protection against replay attacks. Bob claims that it does or does not, depending on "whether the protocol is used carefully." Chris claims it provides no protection against replay attacks. Who is right? Explain.

## Problem 5: QoS problem

Three flows A, B, and C arrive at a router with a WFQ scheduling policy. Assume packets from each flow arrive often enough that the router always has at least one packet queued for each flow. Flow A has reserved $\frac{2}{3}$ of the throughput on the outgoing link. Flow B has reserved $\frac{1}{4}$ of the throughput on the outgoing link. Flow C has reserved $\frac{1}{12}$ of the throughput on the outgoing link. All packets are the same size.

The WFQ scheduler in this problem is roughly modeled after a "general processor sharing" model. At the start of each packet time slot, each flow receives credit proportional to its weight (not unlike a token bucket, except that there are multiple flows). Next, the flow with the most credit is chosen to send a packet in that slot. If two or more flows have the same amount of credit, the router prefers A, then B, then C. Of course, each time the router sends a packet on behalf of a flow, that flow's credit is reduced appropriately (again similar to a token bucket). Note that, unlike a token bucket, a flow's credit value may be negative.

Describe in full the order in which packets leave the router. Briefly explain your reasoning.