May 7, 2008

Final Exam

EE 6340: Introduction to Telecommunications Networks

NOTE: **Please, complete the following table and keep record of your assignment number.**

First Name	
Last Name	
Student ID	
Assignment #	0

Exercise 1. Consider the graph shown in Fig. 1. Note that a double arrow link in the figure represents two

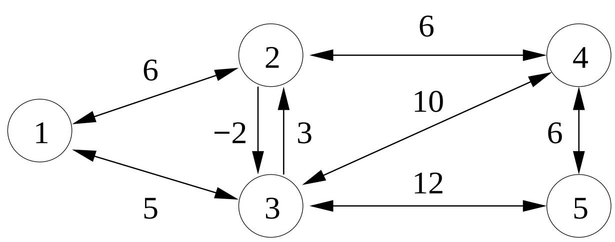

Figure 1: Undirected Graph with 5 vertices.

distinct directed links with opposite directions and same weight. Using a graphical or matrix based representation of each intermediate iteration, find the shortest path from any node to node 1 as indicated below.

A) Run the first three iterations ($h = 3$) of the Bellman-Ford algorithm [pt. 20].

B) Identify the path found from node 5 at the end of the third iteration [pt. 10].

C) Indicate at what iteration (h) the algorithm stops and what is the reason for the algorithm to stop there [pt. 10].

Exercise 2. Consider the flow network shown in Fig. 2. The label on the link indicates the capacity of the

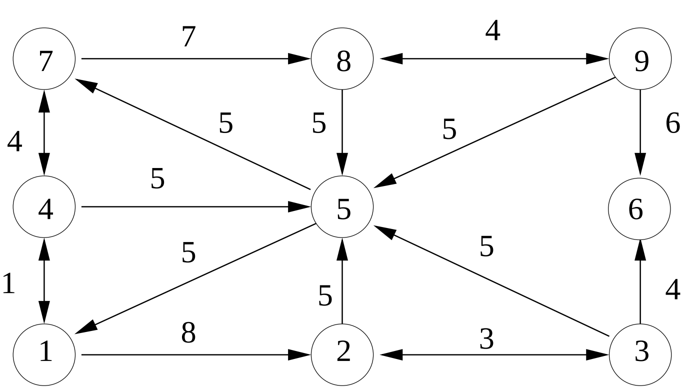

Figure 2: Flow network with directed links.

link. A double arrow link in the figure represents two distinct directed links with opposite directions and same capacity.

A) Using a graphical based representation of each intermediate iteration, find the maximum flow in the flow network from node 1 to 6, and its value. Use a shortest path approach when finding the augmenting path [pt. 20].

B) Determine all the minimum cuts from node 1 to 6 [pt. 10].

C) To increment the maximum flow value you are given the opportunity to update the capacity of only one directed link in the graph. Choose the link to upgrade and the new (minimal) capacity for that link that will maximize the incremental value of the flow. Indicate the resulting (new) maximum flow from node 1 to 6 [pt. 10].

D) Determine all the minimum cuts from node 1 to 6 after the link update [pt. 10].

Exercise 3. Consider a single serve system and two types of job arrivals. Type 1 job arrivals form a Poisson process with rate λ_1. Type 2 job arrivals form a Poisson process with rate λ_2. Service time for type 1 job is exponentially distributed with average $1/\mu_1$. Service time for type 2 job is exponentially distributed with average $1/\mu_2$. Type 1 job can preempt type 2 job. When preempted, type 2 job is discarded, i.e., it will not return to service, and the interrupted service does not count towards throughput. The is no room in the system for a job to wait, i.e., upon arrival either a job can begin service, or it is discarded. Note that this problem cannot be solved using conventional priority queue models, which are designed to model an infinite waiting queue.

A) Determine the stability condition of the queue and build the Markov chain of the system [pt. 20].

B) Using the Markov chain in **A)**, compute the steady state distribution $P(i, j)$, defined as the probability of having i jobs of type 1 and j jobs of type 2 in the system [pt. 20].

C) Compute the probability that upon arrival, a type 1 job is discarded. Compute the same for type 2 job [pt. 10].

D) Compute the percentage of type 2 jobs that upon beginning service are preempted and discarded [pt. 10].

Exercise 4. Consider a closed network of four queues: Q1, Q2, Q3, and Q4. Service time at each queue is exponentially distributed with average $1/\mu_1$, $1/\mu_2$, $1/\mu_3$, and $1/\mu_4$, respectively. Upon completion of service at Q1, a job is equally likely to enter Q2 or Q4. Upon completion of service at Q2, a job is equally likely to enter Q1 or Q3. Upon completion of service at Q3, a job is equally likely to enter Q2 or Q4. Upon completion of service at Q4, a job is equally likely to enter Q1 or Q3. Assume that there is one job only in the closed network of queues.

A) Draw the network of queues, build the Markov chain of the network of queues, and and determine its stability condition [pt. 10].

B) Using the Markov chain from **A)** compute the steady state distribution, i.e., π_1 (job is in Q1), π_2 (job is in Q2), π_3 (job is in Q3), π_4 (job is in Q4) [pt. 20].

C) Compute the same distribution (π_1, π_2, π_3, π_4) using the product form approach and compare with the answer given in **B)** to determine whether or not the product form is applicable in this case [pt. 20].