

Problem Set 4. Due March 13 by 5:00 pm.

Each pair of students only needs to submit one set of answers.

1. Use nslookup to estimate the fraction of the IP address space that is assigned to the publicly accessible Internet. Comment on the need for expanding the IP address space. In the code file you can find a piece of code that generates  $k$  random IP addresses where  $k$  is an argument to the program. Please do not run nslookup on more than 250 addresses. We do not want to start our own Distributed Denial of Service (DDoS) attack on Stanford name servers! [15 pts]
2. One increasingly important use of network models is to determine how a seed investment in advertising will help brand awareness propagate through a network. Consider the following simple scenario: You are given a social network with  $N$  individuals. A company invests  $\$X$  in educating one person, say  $v_1$ , about its product. This person then informs exactly one more person,  $v_2$ , chosen uniformly at random from the remaining  $N - 1$  individuals, about the product. The newly educated person  $v_2$  then informs one more person  $v_3$ , chosen uniformly at random from the remaining  $N - 1$  individuals (i.e. other than  $v_2$ ), about the product, and so on, forming a chain. The process terminates when the chain revisits an already informed individual. For example, if  $v_3 = v_1$ , the process terminates and only two individuals,  $v_1$  and  $v_2$  get informed; in this case we will say that the length of the chain is 2.
  - (a) With what probability is the length of the chain at least  $k$ ? [5 pts]
  - (b) Assume that the expected length of the chain is  $aN^e$  and estimate the exponent  $e$ . You can use the code given in the code file for generating the average length of the chain over  $K$  iterations, or write your own code for either simulating the length of the chain or computing it directly. [15 pts]
  - (c) Comment on the power of viral marketing. [5 pts]
3. Imagine that you are downloading a very large file, say 10GB, which is going to take you a full day to download. But assume that the lifetime of a peer is only 12 hours. Which of BitTorrent and Kaaza is more likely to result in a successful download? Why? Assume that supernodes and torrent servers (called trackers in BitTorrent) don't go down. [10 pts]
4. Read the following article on how BitTorrent works: <http://torrentfreak.com/why-bittorrent-works>. What is free-riding? How does BitTorrent prevent free-riding? Is it impossible to free-ride in BitTorrent? [15 pts]
5. It was mentioned in class that Internet Service Providers may throttle peer-to-peer traffic<sup>1</sup>. This is related to network neutrality. Briefly describe what network neutrality is, and summarize both sides of the debate. [15 pts]

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<sup>1</sup>E.g., <http://www.dailytech.com/More+ISP+Confess+We+Throttle+P2P+Traffic/article9544.htm>