EE 565 Mini-Project 1, Winter 2008

Simulation and Evaluation of Multiple Access Protocols
Submit Online by 10:30AM on 04 February 2008

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1 Project Description

The goal of this project is to simulate and evaluate the ALOHA and slotted ALOHA multiple access protocols for a single broadcast channel of bandwidth R bps with no propagation delay. You will be responsible for writing the simulation code to generate random data traffic and the simulation code for the multiple access protocols themselves. You may use any (reasonable) programming language (MATLAB is recommended for ease of presentation). Prepare a short (1-3 page) project write-up containing the following:

- A brief summary of the project,
- Any assumptions you had to make (e.g. parameters, unspecified quantities),
- A summary of your results and figures, and
- A description of your implementation.

Create a .zip, .tar, or .rar archive including (1) your project write-up, (2) your source code, and (3) a text file with instructions to run your code. Submit this archive according to the online submission instructions.

2 Generating Random Data Traffic

For the purposes of this project, assume that all data packets are a fixed length L. Suppose that packets arrive with rate λ such that the packet inter-arrival times are characterized by a CDF F, i.e. $F(t)$ is the probability that two packets arrive within t seconds.

Let T denote the vector of packet arrival times t_j, i.e.

$$T = \left(t_1, t_2, \ldots, t_{|T|}\right),$$

such that $t_j < t_{j+1}$ for all $j = 1, \ldots, |T| - 1$. Each element t_j of T is constructed by generating a random variable x_j using the CDF F and adding it to the previous element t_{j-1} (only if $j > 1$).

Q1: Let X be a (continuous or discrete) random variable with CDF F, and let U be a (continuous) uniform random variable on the interval $[0, 1]$. Prove that X can be generated from U as $X = F^{-1}(U)$ (where the inverse is properly defined for discrete CDFs). Generate sample distributions (generate a histogram and scale it to be a valid PDF) as follows. (a) Let X be an exponential random variable with mean 1, and generate sample PDFs with 10^3, 10^4, and 10^5 sample points. (b) Let X be a Poisson random variable with mean 5, and generate sample PDFs with 100, 500, and $1,000$ sample points. For (a) and (b), plot the sample PDF and the theoretical PDF f for comparison.

3 ALOHA

Implement the pure (unslotted) ALOHA protocol with exponential inter-arrival times. A transmission at time t_j will be successful if and only if there is no interfering transmission, i.e. if the total number of transmissions in the interval $[t_j - \Delta, t_j + \Delta]$ is 1, where $\Delta = L/R$ is the transmission time for a single packet. If the packet transmission is not successful, it will be retransmitted with probability p at each time $t_j + k\Delta$, for $k = 1, 2, \ldots$, until the transmission is successful.

Q2: Vary the packet generation rate λ from $\Delta/100$ to Δ and vary p from 0.01 to 0.5. For each λ and p, plot the throughput S as a function of the attempted rate G. Plot the average waiting time as a function of λ and p.

Q3: Repeat **Q2** for the slotted ALOHA protocol using similar techniques. A transmission in slot k will be successful if and only if there is no interfering transmission in slot k, i.e. if the total number of transmissions in the interval $((k-1)\Delta, k\Delta]$ is 1. If the packet transmission is not successful, it will be retransmitted with probability p in each slot until the transmission is successful.

4 Wireless ALOHA with Spatial Reuse

Suppose that wireless packet transmissions only interfere between users within transmission range r and that each packet is transmitted at a uniformly random location in the area $[0, 1]^2$.

Q4: Investigate the effect of spatial reuse on the ALOHA multiple access protocol. Repeat **Q2** and **Q3** in this model to investigate the effect of spatial reuse on the ALOHA protocol. Vary r from 0.05 to 1.5 and discuss the effect of r on the system throughput.

5 Optional Extensions

If you're interested, you can extend the project.

- Perform a similar simulation study of the Ethernet protocol with the Binary Exponential Backoff Algorithm.
- Perform a similar simulation study of any of the variety of CSMA multiple access protocols.