CS 455 - Introduction to Computer Networks
Homework 5

Due date: see **class webpage**

- **Question 1 (20 pts)**
  - Two nodes **A** and **B** use **slotted Aloha** to access a **channel**

    We observed the interactions of the two nodes for a **long time** and **found** that:

    - Node **A** transmits in **40%** of the **slots**
    - Node **B** transmits in **30%** of the **slots**

    Based on these **observations**, we will **assume** that:

    - Node **A** transmits in a **slot** with probability **0.4**
    - Node **B** transmits in a **slot** with probability **0.3**

    Questions:

    - What is the **probability** that node **A** completes a **transmission** ***successfully*** in a slot ?

    - Let P_A be the **probability** that node **A** completes a **transmission** ***successfully*** in a slot (= the **answer** in the **previous question**)

      What is the **probability** that node **A** succeeds **for the *first* time** in **slot 3** ?

      Express your **answer** using P_A **only**:

    - What is the **probability** that node **B** completes a **transmission** ***successfully*** in a slot ?

    - What **fraction** of **slots** will contain **successful transmission** ?

* **Question 2 (20 pts)**

  * In an **Aloha network**, the **arrival rate** is **20 messages per sec**

    Messages have the **same** length and it takes **0.1 sec** to transmit a message.

    * What is the **throughput** if the **Aloha** network uses ***unslotted* transmissions** (10 pts)

    * What is the **throughput** if the **Aloha** network uses ***slotted* transmissions** (10 pts)

* **Question 3 (20 pts)**

  * The **maximum network diameter** in **Ethernet** is **2500 m (= meter)**.

I.e.:

- the **distance** between ***any* two nodes** on an **Ethernet** is **at most 2500 m**.

- The **speed** of **electrical signals** in **copper** is **2×10^8 m/sec**.

  Question:

  - What is the **maximum end-to-end propagation delay** in **Ethernet** ? (10 pts)

    (What is the **maximum propagation delay** from **one end** of the **Ethernet** to the ***other* end**)

At time $t = 0$, an **Ethernet host** senses that the **Ether channel** is **idle** and **transmits**.

As you know, the **Ethernet** uses **CSMS/*CD*** and **Ethernet hosts** will **sense the channel** (while it is transmitting) for possible **collision**.

Question:

- After **how many seconds of sensing** can this **Ethernet host** be **100% certain** that there **will not** be **any collisions** ?

  I.e., when can it stop sensing (because it is sure there won't be a collision). (10 pts)

- **Question 4 (40 pts)**

- (This question is adapted from Question 37 in the text book on page 164. --- from an old edition :))

  Let **A** and **B** be two **Ethernet hosts** attempting to transmit on an **Ethernet network**. Each host has a **steady queue of frames** ready to send.

  A's frames will be numbered as A_1, A_2 and so on, and **B's** frames will be numbered as B_1, B_2 and so on.

  The **backoff time unit T = 50 micro seconds**.

  Suppose **A** and **B** ***simultaneously* (= at the same time)** attempt to send **frame 1** and the **transmissions** collide. Then **A** chooses **backoff time 0×T** (i.e., **A** picked the **random number 0**) and **B** chooses **backoff time 1×T**. So **A wins the race** and **transmits** its first frame A_1 ***successfully*** (in the mean time, when **B** retries at time **1×T**, **B** will sense **A**'s transmission; so **B** will wait for **A** to finish its transmission.)

  Fact:

  - **At the end** of **A's** transmission, **B** will attempt to transmit frame B_1 and **A** will attempt to transmit frame A_2.

    A and **B**'s transmissions will **collide** and both nodes will **backoff**.

    A will **back off** picking a **backoff time** from: **0×T** or **1×T**

    B will **back off** picking a **backoff time** from: **0×T**, **1×T**, **2×T** or **3×T**

    Each backoff time period is selected with *same* probability (= equally likely) each outcome is equally likely. In other words:

    - **A** selects **0×T** and **1×T** each with probability **0.5**
    - **B** selects **0×T**, **1×T**, **2×T** and **3×T** each with probability **0.25**

  Questions:

  - Find the **probability** that **A** will **win** the ***second* backoff race** (10 pts)

  - Find the **probability** that here is a **collision** in the ***second* backoff race** (10 pts)

Suppose **A** wins the **second backoff race**.

A will now attempt to transmit frame $\mathbf{A_3}$ while **B** is still attempting to transmit frame $\mathbf{B_1}$.

B will now pick a back-off time from 0×**T**, 1×**T**, 2×**T**, 3×**T** 4×**T**, 5×**T**, 6×**T**, and 7×**T** - each outcome is equally likely.

Question:

- Find the **probability** than **A** **wins** the ***third*** **backoff race** (10 pts)

- Find the **probability** that there is a **collision** (10 pts)