

15-744 Computer Networks — Spring 2016

Homework 1

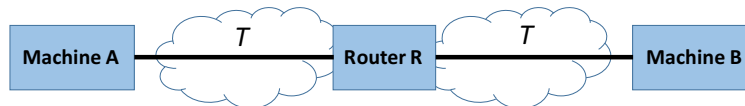
Due by 2/12/2016, 10:30am

(to be submitted in the beginning of class in hard copy)

Name:

A End-to-End Argument

1. Suppose machine A and machine B are connected to two subnets, which are inter-connected by a border router R. Any packet sent by A to B traverses a path from A to R, and then a path from R to B. Suppose the time for a packet to traverse from A to R is always T , and from R to B is always T as well. Also, suppose that the path from A to R drops a packet with a probability of $1 - p$, and the path from R to B drops a packet with a probability of $1 - p$ as well. We only consider packet sent by A to B, and assume the acknowledge from B to A is 100% reliable, and has no delay.



Now, we have implemented a simple program X to ensure reliable data communication between A and B. Initially, you install X on both A and B. When A sends a packet to B, the program X running on B will wait for $2T$, and if there is no packet received by B (due to packet loss on $A \rightarrow R$ or $R \rightarrow B$), X running on A would immediately resends the same packet again.

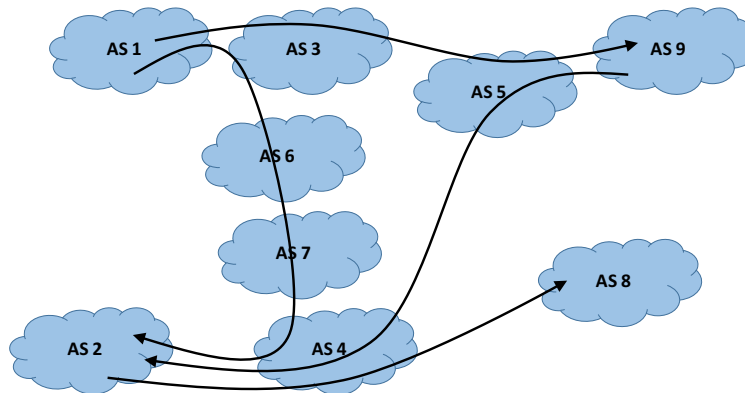
- (a) Under the condition of $p = 100\%$ (i.e., zero drop rate), the expected time for A to successfully send a packet to B is $2T$. Now, what is the expected time for A to successfully send a packet to B in general, i.e., $p < 100\%$?
- (b) Now, suppose you also install X on router R (assume it has the capability to run such a program). When A sends a packet to B, it will first send it to R, and R will wait for time T (not $2T$). If no packet is received by R, A will immediately resend the same packet. Similarly, when R receives the packet, it immediately sends it to B, and B will then wait for time T , and if no packet is received by B, R will immediately resends the same packet. With X installed on all A, B, and R, what is the expected time for A to successfully send a packet to B?
- (c) Of course, the time to send a packet from A to B reliably decreases if X also runs on R, however it comes with a cost (in this case, changing the router). According to the End-to-End Argument, this cost can only be justified if there is significant performance benefit (in this case, the time to send a packet successfully). Assume that the cost can be justified only if the time to send a packet is reduced by at least 30%. Should one install X on R, in addition to A and B if the $p = 99\%$? What if $p = 70\%$?

B BGP

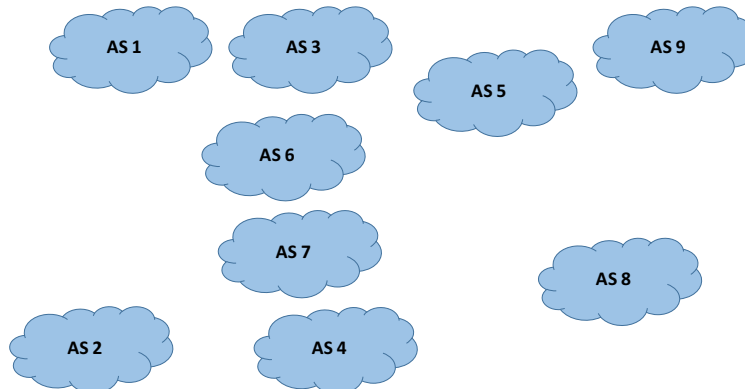
2. The following figure shows 4 AS paths in the network.

- Path 1: $1 \rightarrow 3 \rightarrow 5 \rightarrow 9$
- Path 2: $1 \rightarrow 3 \rightarrow 6 \rightarrow 7 \rightarrow 4 \rightarrow 2$
- Path 3: $9 \rightarrow 5 \rightarrow 4 \rightarrow 2$
- Path 4: $2 \rightarrow 4 \rightarrow 8$

In this network, AS 4 is the only tier-1 ISP. There is a copy of the figure without paths at the end of the question which you can use as a working area.



- (a) Assume in the network there is only customer-provider relationship. Please mark the edges in the figure below the customer-provider relationship (customer \rightarrow provider).

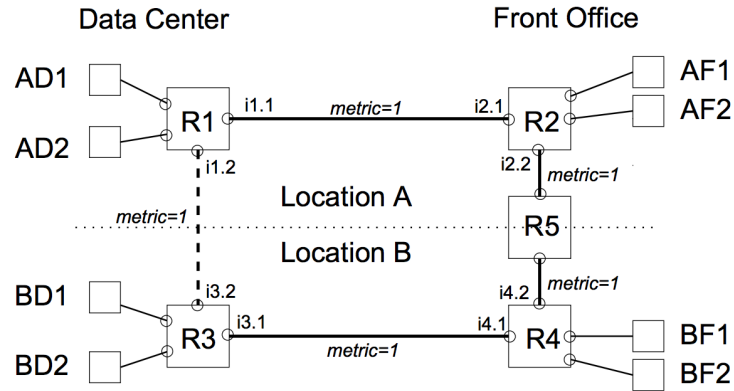


- (b) Assume there is also peering relationship in the network, please identify one possible peering relationship.

- (c) Explain why in the network, AS 4 is most likely the top provider.
- (d) Topologically, there is a shorter path between AS 1 and AS 2 through $1 \rightarrow 3 \rightarrow 5 \rightarrow 4 \rightarrow 2$. Do you think, under the existing customer-provider relationship, BGP should use this path, why or why not?
- (e) Topologically, there are two paths between AS9 and AS 8, $9 \rightarrow 5 \rightarrow 4 \rightarrow 8$, and $9 \rightarrow 5 \rightarrow 3 \rightarrow 6 \rightarrow 7 \rightarrow 4 \rightarrow 8$. Are they both valid under valley-free BGP? If they are not, please explain why. If they are, please explain which is in the best position to enforce one path, not another and how does it enforce?

C SDN

3. In Section 2 of the 4D paper, the authors use two example scenarios to motivate the needs for a more flexible management architecture. However, it falls short of describing how exactly a new management architecture addresses the issues. The Ethane paper proposes a concrete way to enforce management policy. Let's see what will happen if Ethane architecture is applied to the first examples in 4D paper.



- (a) If the only goal is to deny hosts in AF to access data center BD, which router (among R1, R2, R3, R4, R5) will you replace with an Ethane-enabled router (the router that communicate with the Ethane Controller)? How will the Ethane controller enforce the policy?
- (b) If in addition to the first goal, we also want to allow hosts in AF to access hosts in BF via R1 and R3 as a backup route of direct path between R2 and R4. How will the Ethane controller enforce the policy?

D Switch Design

4. Consider an $N \times N$ switch (N input ports, N output ports) that implements iSLIP scheduling algorithm. Assume the traffic is uniform distributed and each input port has queued cells for every output.
 - (a) What is the probability for a given input port to receive grant from a particular output port?
 - (b) What is the probability to receive no grant for this input port?
 - (c) What is the asymptotic approximation when N tends to be infinity?

E Basic Tools

5. Take a look at the man pages for `traceroute` to answer the following questions.

Perform a `traceroute` on `www.berkeley.edu` at three different hours of the day (submit the times as part of the homework).

1. Find the average and standard deviation of the round-trip delays at each of the three hours.
2. Find the number of routers in the path at each of the three hours. Did the paths change during any of the hours?
3. Try to identify the number of ISP networks the `traceroute` packets pass through from source to destination. Routers with similar names and/or similar IP addresses should be considered as part of the same ISP. In your experiments, do the largest delays occur at peering interfaces between adjacent ISPs?
4. Repeat the above for a destination on a continent different than the source. Compare the intra- and inter-continent results.
5. What kind of problem do you expect to be able to solve using `traceroute`?