Internet Routing

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November 4, 2020

Outline

- Routing information. It is about network information sources. Routing information typically have information about network topology and delay
- Routing algorithms. They are the algorithms used to make a routing decision basedon routing information.
- Routing protocols. They specify formats, synatax, and timing of information exchange for routing.

Outline

How to assign a cost to a link?

Below are some examples,

- Using queue length of a link (see the example in Figure 19.4[1]).
  - It does not consider link bandwidth
  - Processing time also impacts queue length
  - It responds slowly to congestion and delay increases
  - It can also vary rapidly, which results in thrashing
- Measuring delay directly (by recording arrival time, departure time, and arrival time of acknowledgement)
  - The estimated delay does not correlate well with actual delay experienced by a packet under heavy load.
  - Example. Figure 19.7 [1]
- Estimating the link utilization (based on queueing models)

[1] William Stallings. *Data and Computer Communications*. 10th. USA: Prentice Hall Press, 2013. ISBN: 0133506487.

Figure 19.7[2]

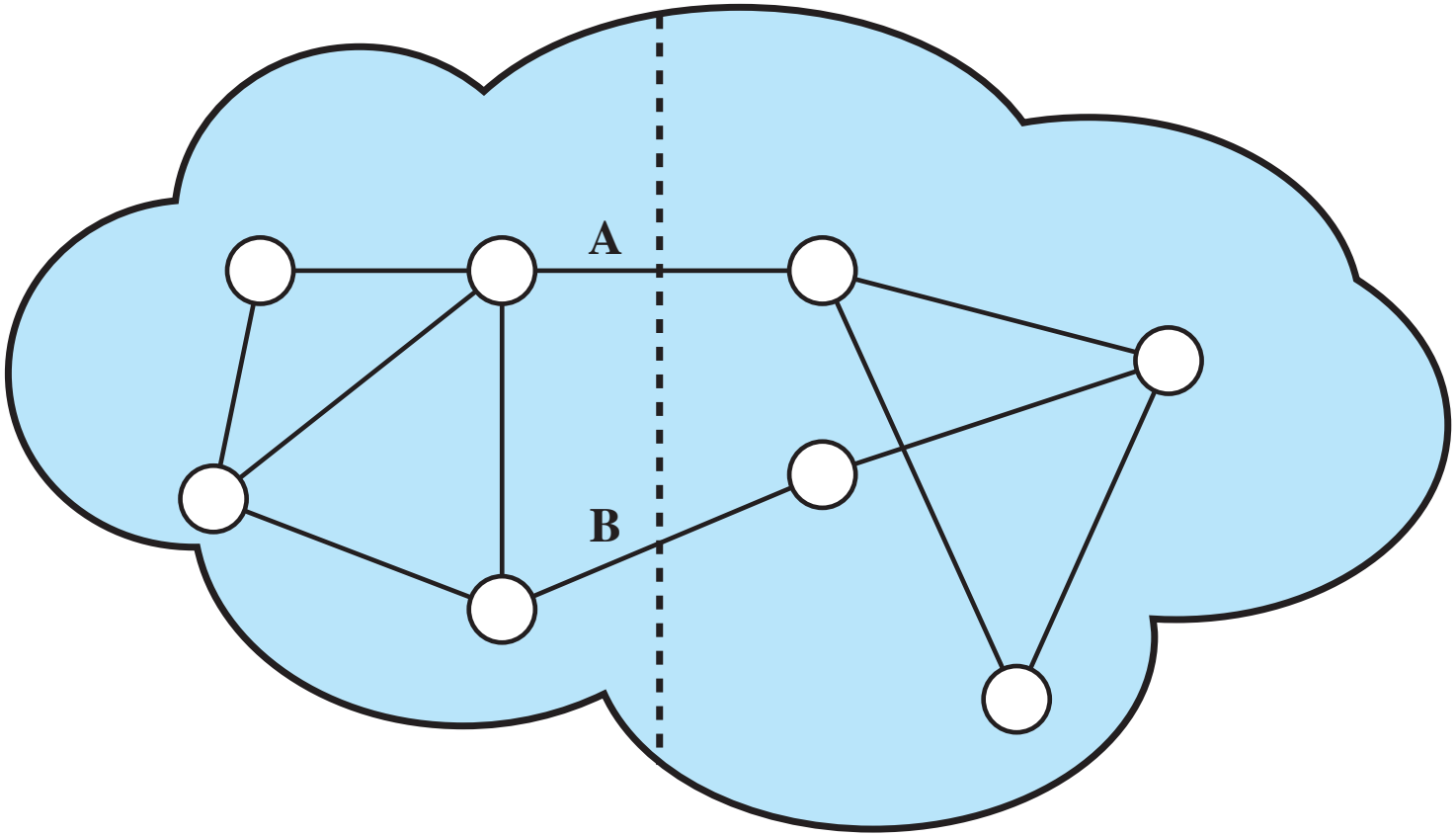

Figure 19.7 Packet-Switching Network Subject to Oscillations

[2] William Stallings. *Data and Computer Communications*. 10th. USA: Prentice Hall Press, 2013. ISBN: 0133506487.

Estimating Link Utilization

1. Estimate utilization

$$\rho = \frac{2(T_s - T)}{T_s - 2T} \tag{1}$$

2. Apply exponential averaging

$$U(n+1) = \alpha\rho(n+1) + (1-\alpha)U(n) \tag{2}$$

where α is typically $\frac{1}{2}$.

Outline

Autonomous System (AS)

- The Internet is an internetwork consisting of networks that are independently controlled and managed.
- As part of the design of the Internet, the Internet composes of autonomous systems(AS).
- An AS has the following characteristics.
  - An AS is an internetwork managed by a single organization.
  - An AS has a group of routers exchanging routing information via a common routing protocol
  - Except in times of failure, an AS is connected, i.e., there is a path between any pair of routers within.
  - An AS is identified by an AS number (public AS numbers, like IP addresses are assigned by the Internet Assigned Number Authority)

Interdomain and Intradomain Routing

- Intradomain routing. Routing among routers within an autonomous system.
  - Interior router protocol
  - Distance-vector and link-state routing
    - Distance-vector. Routers exchange distance-vector containing path costs with their neighbors
    - Link-state. Routers propagate link states containing path costs with all the other routers (via flooding).
- Interdomain routing. Routing among routers in different autonomous systems.
  - Exterior router protocol (ERP)
  - Path vector routing
    - Link cost estimation unreliable crossing multiple autonomous systems
    - Autonomous systems may use different metrics and have different restrictions or prohibitions.
    - Flooding is unmanageable.

Link-State Routing

- Let's examine how it works
- Let's set it up on an internetwork

Border Gateway Protocol (BGP)

Let's examine how it works.