COMP2322 Computer Networking

Homework 5

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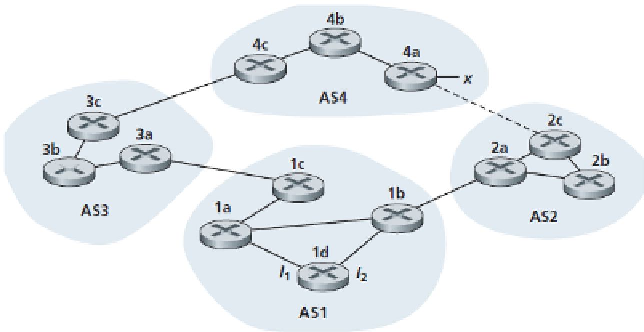
Questions

Question 1

(2 points) Consider the network shown below. Suppose AS3 and AS2 are running OSPF for their intra-AS routing protocol. Suppose AS1 and AS4 are running RIP for their intra-AS routing protocol. Suppose eBGP and iBGP are used for the inter-AS routing protocol. Initially suppose there is no physical link between AS2 and AS4.



From which routing protocol: OSPF, RIP, eBGP, or iBGP, do the following routers learn about prefix x? Justify your answer.

a) Router 3c (1 point)
b) Router 1d (1 point)

Question 2

(4 points) Referring to the previous problem, once router 1d learns about x it will put an entry (x, I) in its forwarding table. What is the value of I? (1 point)

a) Will I be set to I1 or I2 for this entry? Why? (1 point)
b) Now suppose that there is a physical link between AS2 and AS4, shown by the dotted line. Suppose router 1d learns that x is accessible via AS2 as well as via AS3. Will I be set to I1 or I2? Why? (1 point)
c) Now suppose there is another AS, called AS5, which lies on the path between AS2 and AS4 (not shown in diagram). Suppose router 1d learns that x is accessible via AS2 AS5 AS4 as well as via AS3 AS4. If the shortest AS path first policy is applied, will I be set to I1 or I2? If the hot potato protocol is applied, will I be set to I1 or I2? Justify your answers. (2 points)

Question 3

(4 points) We consider the use of small packets for Voice-over-IP applications. Suppose that the packet consists of L bytes of data and 5 bytes of header.

a) A small packet size causes a fraction of link bandwidth to be consumed by overhead. The transmission overhead can be defined as the percentage of the amount of transmitted overhead bits relative to the total amount of transmitted bits. Determine the transmission overhead for $L = 1000$ bytes and for $L = 100$ bytes. (2 points)

b) Consider sending a digitally encoded voice source directly. Suppose the source is encoded at a constant rate of 128 kbps. Assume each packet is entirely filled before the source sends the packet into the network. The time required to fill a packet is the packetization delay. Packetization delays larger than 20 msec can cause a noticeable and unpleasant echo. In terms of L bytes, determine the packetization delay formula in milliseconds. Also, calculate the packetization delay for $L = 1000$ bytes and for $L = 100$ bytes. (2 points)

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Answers

Answer 1(a)

> **Answer:** Router `3c` learns about prefix `x` via **eBGP**. This is because Router `3c` is the edge router of `AS3`, which is directly connected to `AS4` (where prefix `x` is in). Therefore, `3c` directly receives information about `x` from inter-AS communication.

Answer 1(b)

> **Answer:** Router `1d` learns about prefix `x` via **iBGP**. This is because `1d` is **not** the edge router of its AS. Therefore, it cannot directly receive information about `x` from another AS via eBGP. Instead, information is propagated to `1d` from the border router of `AS1` via intra-AS communication iBGP.

Answer 2(a)

> **Answer:** `I` will be **set to `I1`**, because information about prefix `x` reaches `AS1` via `1c`. And the shortest path from `1d` to `1c`, according to RIP, is `1d` → `1a` → `1c`.

Since there are initially "no physical link between AS2 and AS4", the only way for prefix `x`'s existence to propagate all the way to `1d` is via:

`AS4` → `AS3` → `AS1` → `1c` (`AS1`′s border router)

After information reaches `AS1`, it will be propagated to `1d` via intra-AS communication iBGP. Next, IGP will be applied to determine the optimal path `1d` → `1c`. Because `AS1` utilizes RIP, which uses hop count as its distance metric, the optimal routing path within `AS1` is

`1c` → `1a` → `1d` (via `I1`)

Answer 2(b)

> **Answer:** `I` will be **set to `I2`**. Since the inter-AS hops are the same whether going through `1c` or `1b`, then, ceteris paribus, the path `1d` → `1b` is chosen for having fewer hop counts.

With the new link between AS2 and AS4, router `1d` now learns two paths to x:

- `AS4` → `AS3` → `AS1` → `1c`
- `AS4` → `AS2` → `AS1` → `1b`

Both paths have the same inter-AS hop counts. Then, assuming other attributes like local preference value attribute (policy) are also the same, the BGP decision process proceeds to compare the IGP cost from `1d` to the two border routers, `1c` and `1b`.

Based on the RIP, the shortest paths are (based on hop counts):

- `1d` → `1b` (via `I2`) - then entering `AS2`
- `1d` → `1a` → `1c` (via `I1`) - then entering `AS3`

Therefore, `I2` is preferred for having the least hop counts.

Answer 2(c)

> **Answer:**
> - If shortest AS path first policy: **link `I1`**
> - If hot potato policy: **link `I2`**

If shortest AS path first policy:
- If we choose the path `AS2,AS5,AS4`, then `I2` will be chosen
- If we choose the path `AS3,AS4`, then `I1` will be chosen

Since inter-AS hops is minimized, `AS3,AS4` is better. Hence `I2` will be chosen.

If hot potato policy: Hot potato policy choose local gateway that has least intra-domain cost (don't care about inter-AS hops). Then, from the previous analysis in **2(b)**, link `I2` will obviously be chosen.

Answer 3(a)

> **Answer:** When L = 1000 bytes: 0.498%; When L = 100 bytes: 4.76%

For $L = 1000$ bytes:

$$\text{Transmission Overhead} = \frac{\text{Transmission Overhead Bits}}{\text{Transmission Total Bits}} = \frac{5}{L+5} = \frac{5}{1005} \approx 0.498\%$$

For $L = 100$ bytes:

$$\text{Transmission Overhead} = \frac{\text{Transmission Overhead Bits}}{\text{Transmission Total Bits}} = \frac{5}{L+5} = \frac{5}{105} \approx 4.76\%$$

Answer 3(b)

Answer:

$$\textbf{Packetization Delay} = \frac{\boldsymbol{L}}{\mathbf{16000}}\ \textbf{sec}$$

- Delay when $L = 1000$ bytes: **62.5 ms** (cause noticeable echo)
- Delay when $L = 100$ bytes: **6.25 ms** (does not cause noticeable echo)

Packetization Delay Formula:

$$\begin{aligned}\text{Packetization Delay} &= \frac{\text{Packet Data Size}}{\text{Encoding Bitrate}}\\ &= \frac{L \times 8 \text{ bits}}{128 \text{ kbps}}\\ &= \frac{L}{16000} \text{ sec}\end{aligned}$$

For $L = 1000$ bytes:

$$\text{Packetization Delay} = \frac{1000}{16000} = 0.0625 \text{ sec} = 62.5 \text{ ms}$$

For $L = 100$ bytes:

$$\text{Packetization Delay} = \frac{100}{16000} = 0.00625 \text{ sec} = 6.25 \text{ ms}$$