IERG 5090
Advanced Networking Protocols and Systems
Homework Assignment 1
Due: Mar. 7, 2017

1. For the Link State Routing example on page 34 of Lecture 2, we considered route computation from the vantage point of Node C.
   a) What are the Link State Packets seen by Node B? (5pts)
   b) Show the best routes (using Dijkstra's algorithm) for Node B, in the same fashion as we did for Node C. (10pts)

2. A big challenge for Link State Routing is to distribute the Link State packets (LSP) from each router to all other routers, on a periodic basis. Instead of distributing the LSP on a periodic basis, how about designing a reliable protocol so that the source of LSP will only distribute a new LSP when there is some change from the old one? Discuss the new challenges for this approach. (Note: this is open question – there is no standard answer. The purpose is to encourage critical thinking). (15pts)

3. In the class, we explained that a transit provider ISP commonly charges a customer ISP on a monthly basis based on transit traffic. The charge is usually computed based on the 95-percentile rule, for traffic in all the 5-minute intervals in a month.
   a) What is the monthly traffic pattern most beneficial to the customer ISP, if we assume the customer wants the provider to transit as much traffic as possible for a given price? (5pts)
   b) What is the monthly traffic pattern least beneficial to the customer ISP, under the same assumption as in (a)? (5pts)
   c) Discuss what will happen if the median (50-percentile) is used instead, to your traffic patterns in (a) and (b)? (6pts)
   d) Discuss how it affects the customer and provider if the charge is based on total traffic volume in a month. Discuss what type of customers would prefer total volume charging than 95-percentile charging? (9pts)

4. In the BGP protocol, most attributes are used in eBGP (between routers from different ISPs), while some are used in iBGP (between routers from the same ISP).
   a) Is the LOCAL_PREF attribute used in eBGP or iBGP? (3pts)
   b) Is the COMMUNITY attribute used in eBGP or iBGP? (3pts)
   c) Explain briefly in your own words what these two attributes are used for. (9pts)

5. Consider a service provider, called SampleCom, is offering VPN services based on MPLS/VPN technologies. SampleCom has two points of presence (POP), located in City A and City B, respectively. Further, the POPs are connected through a core router located in City C.

   Currently, SampleCom has two customers: SuperBank, with headquarters in City A and branch offices in Citie L and K, and ApeToys, with headquarters in City B and branch offices in Cities M and N. SuperBank also has two other branch offices (located in Cities P and Q respectively) that are linked directly with the SuperBank central site. The whole network is shown in Figure 1.
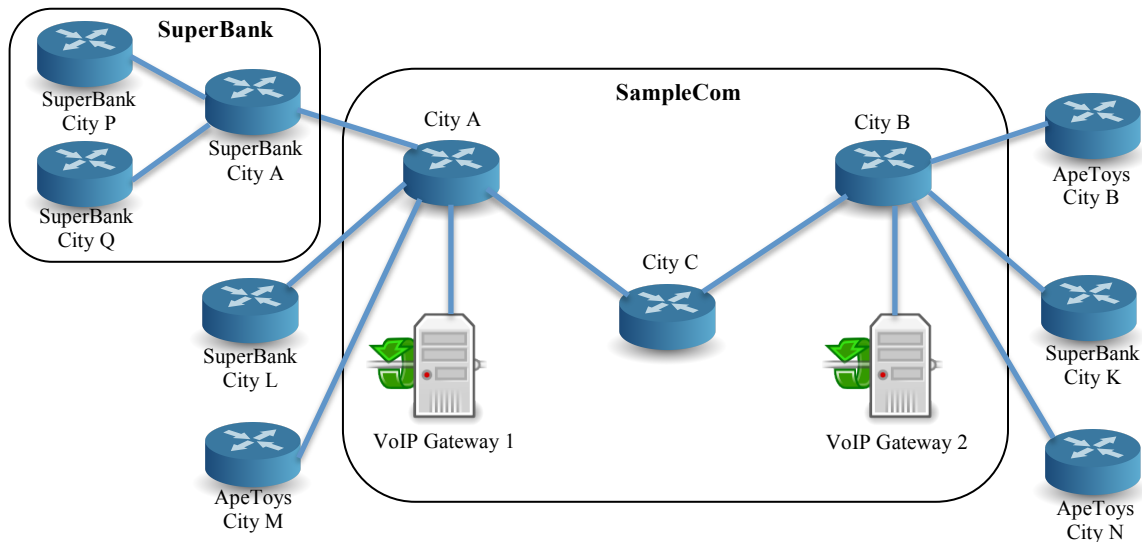

Figure 1. SampleCom Network

Moreover, SampleCom is offering Voice over IP (VoIP) service with gateways to the public voice network located in City A and City B. The VoIP gateways are placed in a separate VPN to enhance the security. Both ApeToys and SuperBank are using this service, but only from their central sites. That is, the central sites of both companies need to be in two VPNs: the corporate VPN to reach their remote sites and the VoIP VPN to reach the VoIP gateways. The connectivity requirements are illustrated in Figure 2.
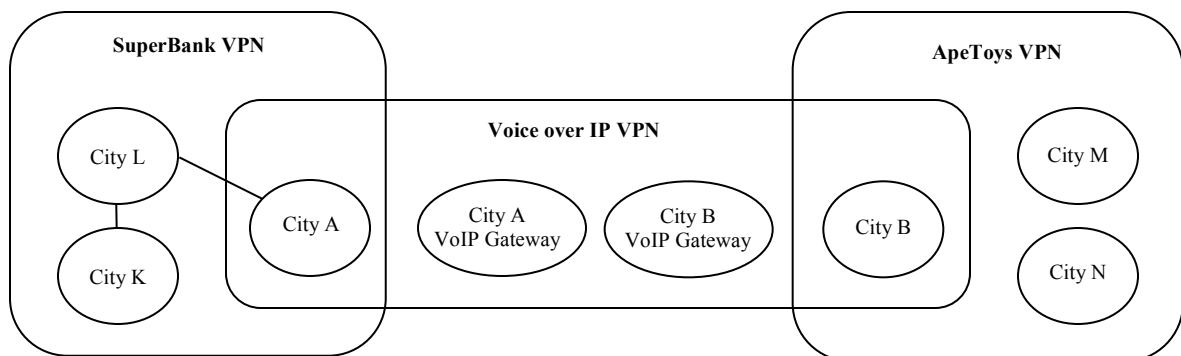

Figure 2. VPN Connectivity Requirements in SampleCom Network

Note that for some security reason, in SuperBank VPN, every packet should go through the branch office in City L. That is, the branch office in City L is acting as the hub while the other two sites, i.e., the central site and the branch office in City K, are spoke sites.

Both companies follow the same addressing convention. The central sites use public IP addresses, whereas all the remote sites use private IP address space (network 10.0.0.0). The IP addresses used by these two companies and the VoIP gateways are summarized in the following table.

Company	Site	IP Prefix/IP Address
SuperBank	City A	195.12.2.0/24
	City L	10.1.1.0/24
	City K	10.1.2.0/24
	City P	10.1.3.0/24
	City Q	10.1.4.0/24
ApeToys	City B	196.7.25.0/24
	City M	10.1.1.0/24
	City N	10.1.2.0/24
SampleCom	City A (VoIP Gateway)	212.15.23.12
	City B (VoIP Gateway)	212.15.27.35

Table 1. Address (Space) of SuperBank, ApeToys and SampleCom

a) Design an MPLS/VPN architecture that supports the connectivity requirements. You can draw a picture similar to that in Page 99 of Lecture Note 6. The answer should include the following information: the VRFs of both PE-routers (in Cities A and B); the sites included in each VRF; the route distinguisher (RD), the import and export route targets (RT), and the assigned VPN labels of each VRF. For each VRF, you should also indicate which VPN it belongs to. (20pts)

b) Assume that the branch office of SuperBank in City P sends a packet to the branch office in City K. Please describe how this packet will be forwarded according to the architecture in a). What CE or PE routers will the packet be forwarded to? How will the labels be pushed, swapped, or popped at each router? (10pts)