The company BEREASY2 Ltd has facilities, headquarters and branches, located in three different cities. The headquarters and branch offices communicate with each other in IP with direct Internet connections over Ethernet at 100 Mb/s and 20 Mb/s, respectively, over a VPN IP provided by ISP1. The VPN only allows the branches to access the Internet via the headquarters. Additionally, at the headquarter building has a second access to the Internet via another ISP, reserved for the *Disaster Recovery* service. The main characteristics of the network infrastructure of the company are listed below, taking into account the maximum number of stations used for each LAN:
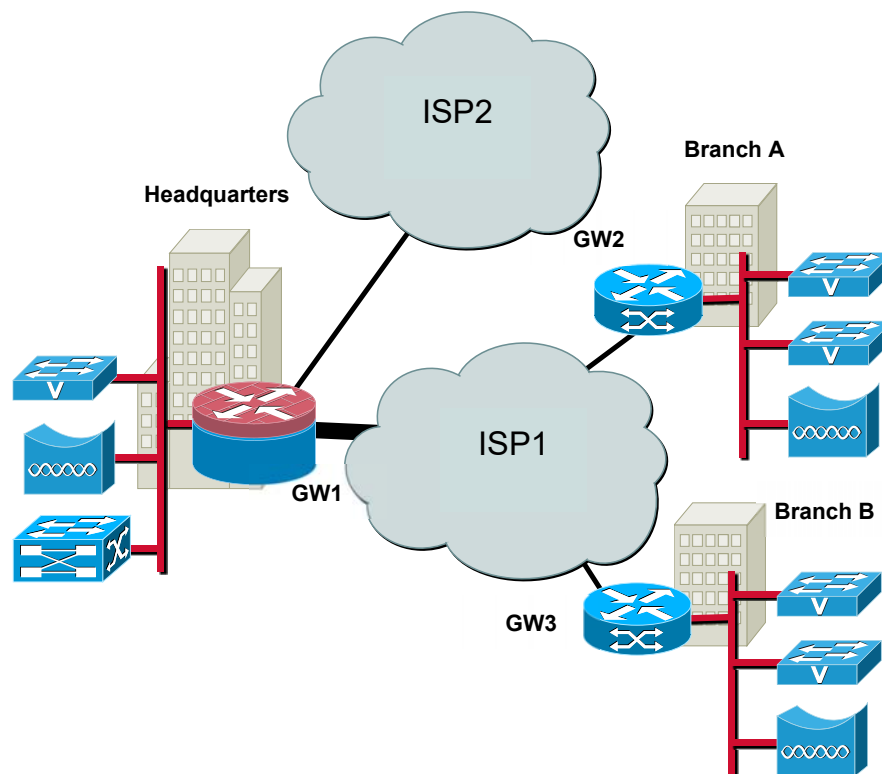
- All services are supported in the TCP / IP protocol stack;

- All routers, GW1, GW2 and GW3 talk to one another in BGP and are within the same Autonomous System (AS);

- In each building of the branch offices are set out:

  - 8 Wi-Fi APs to provide access at any point in the building to 30 mobile stations;

  - 8 Ethernet switches with 24 RJ45 ports at 10/100 Mb/s, and support for *Power over Ethernet* (PoE);

- 4 VLANs (in addition to VLAN1 which is expected to be accessible) with 20 stations in VLAN10 for management and administrative services, 120 stations in VLAN20 for VoIP terminals, 10 stations in VLAN30 to the local servers and 120 stations (including mobile stations) in VLAN40 for regular network users.

- At headquarters are planned:

  - 16 Wi-Fi APs to provide access at any point in the building to 120 mobile stations;

  - 12 Ethernet switches with 48 RJ45 ports at 10/100/1000 Mb/s, and support for PoE;

  - 4 VLANs (in addition to VLAN1 which is expected to be accessible) with 30 stations in VLAN10 for administrative and management services, 300 stations in VLAN20 for VoIP terminals, 20 stations in VLAN30 to servers across the enterprise and 300 stations (including mobile stations) stations in VLAN40 for regular network users.

1. Considering the number of users indicated and assuming that each user has access to a workstation and a VoIP terminal, during working hours from 9:00 until 18:00, consider the following traffic patterns:

- E-mail – each user sends on average 10 Mbyte per day and receives 50 Mbyte. The E-mail servers are housed in the headquarters building. Incoming traffic has the following pattern: about 80 % comes from outside and the rest is internal to the company. Traffic sent have the following pattern: about 50 % intended to address internal to the company, the remaining 50 % to external recipients;

- Web access – Each user accesses on average to 20 Mbyte of enterprise content and 200 Mbyte external content;

- VoIP – On average each user consumes in total 4 MByte incoming and outgoing traffic, 60 % is to outside;

- SAP – Only 10 % of the users of the branches and 20 % of the headquarters building use SAP; the average data transactions are 15 kbyte. Each user makes an average of 20 transactions per day;

- Backup – Is transferred daily from 00:30 to 06:30 a backup of the documents generated locally, from the servers located in the headquarters building to the servers housed in the premises of a service provider, with the average total volume of 10 Gbyte.

a) Which is the flow model that characterizes each of these flows in the network?

   Answer: Considering the given traffic patterns, the flow model for each service is

1.   E-mail – Client-server;

2.   Web access – Client-server;

3.   VoIP – Client-server for SIP negotiation (call setup, negotiation and ending); generally peer-to-peer for voice streaming, except if talkers are behind firewalls;

4.   SAP – Client-server;

5.   Backup – Client-server.

b) Which are the important boundaries in the traffic flows of the corporate network?

Answer: The major hard and soft boundaries are located in the router's interfaces interconnecting headquarters and branches, and to the ISP2.

c) Quantify to approximate values the flows of E-mail, web access and SAP, between buildings.

Answer: Since the headquarters and branch offices communicate with each other over a VPN IP provided by ISP1, and the VPN only allows the branches to access the Internet via the headquarters, the critical flow boundary is the interface of headquarters' router connecting to ISP1.

1. **E-mail**

E-mail servers are housed in the headquarters building

$$300 + 30 + (120 + 20) * 2 = 610 \text{ users}$$

ISP1 Incoming 50 Mbyte * 0,8 = 40 Mbyte / user / 24h

$$(610 * 40 * 8) / 86400 \approx 2,3 \text{ Mb/s}$$

ISP1 Outgoing 10 Mbyte * 0,5 = 5 Mbyte / user / 9h

$$(610 * 5 * 8 * 1024) / 32400 \approx 770 \text{ kb/s}$$

All the e-mail comes from the headquarters' server to each branch

Branch Incoming 50 Mbyte / user / 9h

$$(140 * 50 * 8) / 32400 \approx 1,7 \text{ Mb/s}$$

Branch Outgoing 10 Mbyte / user / 9h

$$(140 * 10 * 8 * 1024) / 32400 \approx 354 \text{ kb/s}$$

2. **Web**

Assuming the internal Web servers are located in the headquarters building

300 + 30 + (120 + 20) * 2 = 610 users

ISP1 Incoming 200 Mbyte / user / 9h

(610 * 200 * 8) / 32400 ≈ 30 Mb/s

For each branch:

Branch Incoming (200 + 20) Mbyte / user / 9h

(140 * 220 * 8) / 32400 ≈ 8 Mb/s

3. **SAP**

SAP servers are located in the headquarters building therefore only will be noticed traffic to the branch offices.

For each branch incoming (140 * 0,1 * 20 * 15) kbyte / 9h

(4200 * 8) / 32400 ≈ 1 kb/s

d) Discuss the available bandwidth to access the Internet in the headquarters, taking into account the values obtained in the previous answer.

Answer: The critical flows boundary is the interface of headquarters' router connecting to ISP1 where all the VPN IP and Internet traffic flows.

Additionally is necessary to compute VoIP traffic and SAP traffic is irrelevant for overall computations.

VoIP

Assuming the iPBX servers are located in the headquarters building:

300 + 30 + (120 + 20) * 2 = 610 users

ISP1 Incoming 4 Mbyte * 0,6 / user / 9h

(610 * 4 * 0,6 * 8 * 1024) / 32400 ≈ 370 kb/s

ISP1 Outgoing 4 Mbyte * 0,6 / user / 9h ≈ 370 kb/s

For each Branch Incoming 4 Mbyte / user / 9h

(140 * 4 * 8 * 1024) / 32400 ≈ 142 kb/s

Incoming = ISP1 e-mail + (mail from branch * 2) + Web + Incoming External VoIP + (Incoming VoIP from branch * 2)

2,3 Mb/s + 354 kb/s * 2 + 30 Mb/s + 370 kb/s + 142 kb/s * 2 ≈ 34 Mb/s

Outgoing = ISP1 e-mail + (e-mail to branch * 2) + (Web branch * 2) + External VoIP + (Outgoing VoIP to branch * 2)

770 kb/s + 1,7 Mb/s * 2 + 8 Mb/s * 2 + 370 kb/s + 142 kb/s * 2 ≈ 13 Mb/s

The bandwidth available in the Internet access of headquarters building is oversized and allows the support of the average traffic and burst peak scenarios.

END