MyCo company's executives have approached you to **architect, design, and recommend** if they should use an **IP network infrastructure for all their applications**.

Here is some information you gathered about the company:

1. **MyCo has 14 locations.** The locations are **1 HQ, 2 regional centers (RC), and 11 local offices (LOs).**

2. About **10,000 people** work in this company, **25% at the HQ, 10% at each RCs, and 5% at each LOs.**

3. The overall topology is tree-like where HQ is connected to the 2 RCs and 5 LOs, and each RC is connected to 3 LOs each. There is no other direct connection (e.g., between RC1 and RC2), or between LOs, etc.
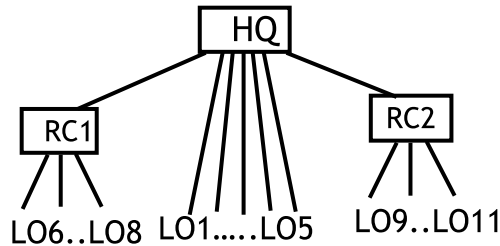
4. **At least 3 different types of major classes of applications** exist today:

   a. **Priority Data** Communications involved in engineering, sales, payroll, marketing, administrative, and operations functions.

   b. **Non-priority data** applications such as e-mail, and data-base update.

   c. **Voice** telephony.

   There may be other applications coming soon, like conferencing, real time video-based training, etc.

5. The **HQ** building houses Management (5%), Administrative and Operations (10%), Payroll (5%), Product Marketing (20%), Engineering (30%), and Sales (30%) people. The **Regional Centers**

both have Admin & Ops (20%), Engineering (40%), and Sales people (40%). The **Local Offices** have only Sales people. Note that %s are given for each location.

6. Here is some more detailed **information on the data applications**:

    1. Engineering access Compute Servers located at the HQ, RC1, and RC2. The engineers run product design related interactive computing applications to Compute Servers. The interactive computing application requires processing 5-10MB files with responses in 0.1 s. We can assume that no more than 10% of the engineers run the interactive computing application at a time in each location.

    2. Engineers also make database inquiries and receive responses. An application for database inquiries (20 KB) and responses (20 MB) take typically 0.5 s. There are also batch database update applications run by engineers, which are 500MB to 2 GB files taking up to 15 minutes. The PM and Sales people only run database inquiry/responses. We can assume that no more than 10% of the engineers, or PMs, or sales people, run the database inquiry/response or the batch database update applications at a time in each location.

    3. All groups use local servers only. The one exception is the Sales people at LOs need to access the Storage Servers at the nearest large office (HQ, or RC1, or RC2) as there is no Storage Server at the LOs. However, for cost savings and based on usage, 2 licenses are bought for the special software needed to access these software per LO location. In other words, only two sales people at a LO can simultaneously access the Storage Servers.

    4. There are also data migrations (backup) between Storage Servers (databases) between the HQ and RC1 and separately between HQ and RC2 locations. These are 100 GB files run at night and takes several hours (~10,000 seconds).

    5. Selected dataset (roughly half of the 100 GB file update mentioned above) is sent from the HQ Storage to an External server separated by a DMZ for access by customers through Internet. The selected dataset upload also happens at night and takes roughly an hour.

    6. There is one Internet Access Server at the HQ which directs all company personnel access to Internet. We heard that for Internet access an average bandwidth of 30 Kbps per user is sufficient and no more than 15% of the employees access Internet concurrently. Internet access is only during day time hours.

Based on the above information, you are asked to provide answers to the following questions:

Q1. (15 points) **Develop traffic flow mapping and performance requirements for flows.**

Q2. (15 points) **Calculate data bandwidth requirements from and to each site**.

Q3. (5 points) This company got a block of network address **150.75.0.0** from ICANN. **Is this a Class A, B, or C address?**

Q4. (15 points) This address block is quite large for them. Given the departments and number of people in each department at all locations (as noted above), **develop a variable-length addressing scheme with some reserved addresses** to accommodate possible future hires and addition of

devices. MyCo suggests **reserving at least 30% more IP addresses for each group**. Be reasonable in your allocation and do not over-allocate addresses. Provide different address blocks for each department at each location for routing and security reasons, and make addresses contiguous; so that the unused address block can be traded or used for future use.

The next three questions relate to voice communications. Note that this topic was not covered in the class, but it is included to encourage self-learning, research, and analysis.

MyCo wants to know the impacts of putting Voice over IP with IP Phones. So, the same IP infrastructure (LAN-WAN) will carry voice as well. Since most other technologies are getting out of favor, it is decided that the **intra-building network will be Ethernet LAN based**.

Q5.   (10 points) For VOIP, first you need to consider the codec to use. Although there are many voice codecs, MyCo wants the safest bet and suggests that you design with the most known and oldest codec G.711 since they are very concerned about the voice quality with VoIP. **Calculate the voice payload from G.711 codecs with 20ms. frames along with the RTP, UDP, IP, and Ethernet overhead to measure the <u>bandwidth per call</u> with G.711**.

Q6.   (10 points) Now, you need to **calculate the bandwidth required for supporting VoIP from each location** based on the number of people at each location but considering that not everyone is going to call at the same time. Assume that no more than 25% of people are on the phone at any particular time at any location. That will give you the total bandwidth required from each location based on the number of people at each location and the required bandwidth per VoIP call that you calculated from Q5.

Q7.   (10 points) The second point to consider is that from each location, some calls are internal to that site and some are going to outside locations. Again, as an approximation, MyCo telecom people suggests to **use a 50-50 rule** (50% internal, 50% going out) **for the LOs and 70-30** (70% internal, 30% going out) **for the HQ and RC** buildings. Given this, calculate bandwidth needed for voice traffic from each location going to other locations. The bandwidth needed for voice calls within each location is not needed because all locations must have broadband connectivity for internal communications.

Finally, answer the following two questions relating to the voice and data converged network over the same IP infrastructure that you designed.

Q8.   (20 points) **Describe various IP-QoS mechanisms** which could be deployed to meet QoS expectations of the users for the data and voice traffic on this network.