Q1. **LEO Constellation:**
What is the benefit of deploying LEO satellite constellations with inclinations lower than 90 degrees?

Why are temporal variations in path latencies critical to end-to-end delay-based congestion control?

What are the consequences of announcing topology changes via BGP? Discuss a strategy to reduce the number of announcements.

Q2. **SDN:**
What are key characteristics of software-defined networks? How are they different from traditional networks?

What are areas of application of SDNs? Are they suitable for all settings (Data Centers, ISPs, the Internet...)?

In traditional data centers with non-virtualized network, moving services (or VMs or tenants) between machines can be difficult. Why? What are the possible solutions?

Suppose an NVP data center has one tenant with 10 VMs and one with 100 VMs. Each tenant allows any communication within its virtual network and no external communication. How many total unidirectional tunnels will be constructed in the data center?

Q3. **QUIC middlebox visibility:** QUIC’s (partial) transport layer header encryption makes a packet more opaque to parties in between the endpoints,
e.g. middleboxes. For example: with TCP, middle parties are trivially able to measure latency by looking at sequence and acknowledgement numbers. With QUIC's (partial) transport layer header encryption, this is now impossible. Certain parties (e.g., ISPs) argue they must be able to measure latency for individual flows to provide certain quality of service guarantees. In response to this, the "Spin bit" has been proposed.

Please note: in this question we use the "Spin bit" as an example. The exact (analysis of the) mechanism of the "Spin bit" is not part of the exam material.

Please read through the following documents:

Spin bit original proposal:

Section 17.3.1 of the latest draft of QUIC:
https://datatracker.ietf.org/doc/draft-ietf-quic-transport/?include_text=1

Answer the following questions about the Spin bit:

- At what interval does the Spin bit provide a new latency measurement?
- To measure, does one need to observe the packets in both directions or only unilaterally?
- How is reordering handled by endpoints?
- Does the Spin bit always measure primarily network latency? In particular, does the application and flow control behavior affect the measurement?

Answer the following questions in general about this topic:

- Which parts of network (i.e., network layer or transport layer) headers must be exposed to the public to fulfill their function? (Extra optional entertaining reading: https://web.archive.org/web/20180314020456/http://www.postel.org/pipermail/end2end-interest/2005-February/004616.html)
- What other current functionality of middleboxes is restricted by QUIC's encryption? Secondly, optionally: choose one of them: can you think of a minimal way (i.e., in the spirit of the spin bit) to continue to accommodate that functionality? (creative question) (extra optional reading: https://blog.apnic.net/2019/03/04/a-quick-look-at-quic/)