Homework Module F
Mobile Networks

Exercise 1. Sequence numbers in MPTCP.

a. Explain why a single sequence space is not enough in MPTCP.

b. A sender has 6 PDUs to send over 3 subflows, each subflow is responsible for sending 2 PDUs. Suppose the Initial Data Sequence Number is 1 and each PDU contains 1 byte of data. Please draw a reasonable sequence mapping on these three subflows.

Exercise 2. Congestion control in MPTCP

In regular TCP, the congestion control algorithm works as follows. For each ACK, increase the congestion window $w$ by $1/w$, resulting in an increase of one packet per RTT. In case of a packet loss, the congestion window is cut by half.

In MPTCP, a connection consists of a set of subflows $R$, each of which may take a different route through the Internet. Each subflow $r \in R$ maintains its own congestion window $w_r$. An MPTCP sender distributes packets across these subflows as space in the subflow windows becomes available. Denote $RTT_r$ as the round trip time experienced by subflow $r$. The windows are adapted as follows:

- For each ACK on subflow $r$, for each subset $S \subseteq R$ that includes path $r$, compute:
  $$
  \min_{S \subseteq R, r \in S} \frac{\max_{s \in S} w_s / RTT_s^2}{(\sum_{s \in S} w_s / RTT_s)^2}
  $$
  then find the minimum over all such $S$, and increase $w_r$ by that much.

- For each loss on subflow $r$, decrease the window $w_r$ by $w_r/2$.

a. What would happen if, instead of using the MPTCP congestion control algorithm as described above, each MPTCP subflow just ran a regular TCP congestion control algorithm on its own.

b. Explain that when an MPTCP connection has only 1 subflow, the congestion control algorithm behaves similarly to regular TCP.