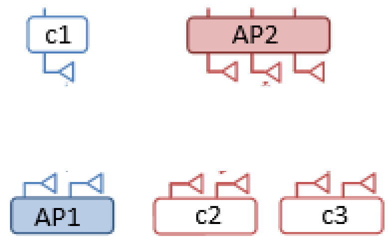
Interference Management

Consider the topology in the figure below which has two access points and three clients.



1) Assume the access points and the clients cannot coordinate over the back end Ethernet. Assume the RED nodes want to communicate with each other and the Blue nodes want to communicate with each other. In this case, what is the maximum number of concurrent packets that you can support given the antennas on the APs and clients? Explain how these packets will be transmitted, i.e., using IA, IAC, IN, MegaMIMO, etc.

2) Assume the two APs can communicate over a back-end Ethernet. However, the backend Ethernet has a limited capacity and hence you cannot simply transmit the I/Q values of the received signal on the Ethernet, you are allowed to transmit only decoded packets. What is the maximum number of concurrent packets that can go over this network? Explain how you would send these packets without interference.

RF-Based Localization

Ben wants to build an RF-based localization system, where he attaches a transmitter to the object of interest and tries to localize it based on the received signal Assume for this question that localized object is far enough from the receiver such that the waves are planer. Ben is considering the following options for his system.

1) Assume that Ben is localizing a transmitter in an open filed with no multipath. Further, Ben knows that the transmitter is between 100+epsilon meters in front of his receiver. He knows that epsilon is about +/-2 meters. Assume the noise is Gaussian and the transmitter does not move and the environment does not change. Ben claims that by making the transmitter transmits at low frequency like 27 MHz, he can find the value of epsilon to an accuracy of one millimeter using a single receiver with only two antennas. Is Ben right? Explain your answer.
2) It turned out that it is very difficult to use low frequency due to FCC regulations. So Ben decided to operate his transmitter and receiver at 2.4 GHz, and use antenna arrays to obtain a good measure of direction. However, since it is very hard to build a very large antenna array, Ben decided to SAR with a single moving antenna as in PinIt paper. Does Ben's scheme work? Explain.
3) Ben clients changed their mind and became interested in locating people without requiring them to hold or carry any wireless device. Ben built a WiTrack device as described in the Witrack paper. However since he is operating in a planer domain (i.e., 2D localization) and he has no multipath effects in his setting, he removed the third RX antenna and operated

using 2 RX antennas. Ben however failed to locate two people with his design. Can you explain to Ben why his device will not locate 2 people? Recall that the environment has no multipath.

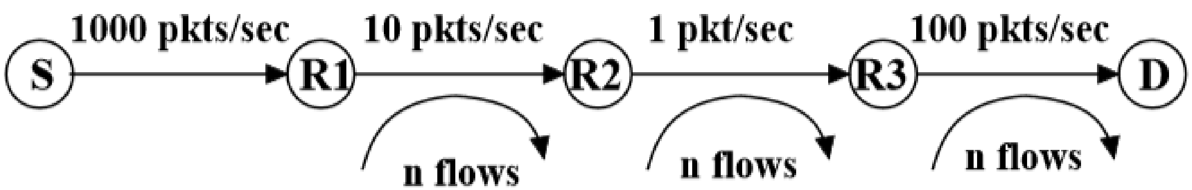
Full-Duplex

Answer true or false. Explain your answer

a. The full-duplex design in Mobicom'10 does not work with multipath even if the channels were narrowband
b. If Picasso could have programmable band-pass filters that filter in the received signal in analog domain, then there is no need for full-duplex to remove leakage.
c. Having a full duplex AP is useless if all clients are single antenna half-duplex nodes.

Packet Pair

Consider the topology in the figure below:



Assume all packets in the network are the same size. Every minute, the sender S sends a pair of back-to-back packets, i.e. with no inter-packet delay. The inter-spacing of the pair changes as it traverses the network. When the destination receives a packet pair, it measures the inter-arrival between the two packets and takes the inverse of that value, call that value Q.

1. Assume n= 0, i.e., there is no cross traffic on this path. Also assume that the routers use FIFO queues. What is the value of Q (circle the right answer)?
   a. 1
   b. 10
   c. 100
   d. 1000
2. Assume all routers along the path use separate queues for each flow and that they transmit packets from these queues using a round robin policy. Further, if a queue does not have a packet when its round robin turn arrives, the queue is simply skipped. Assume also that packets are the same size and that n=9 flows and that all flows send packets as fast as they can without using congestion control. What is the value of Q?
3. Ben claims that if all routers use the queuing policy described in (2) above, i.e., a separate queue for each flow and round robin processing, flows traversing the bottleneck will have a min-max fair share. Explain why Ben is wrong. (Hint, a router has a finite memory that it allocates to packets on arrival as it queues them.)

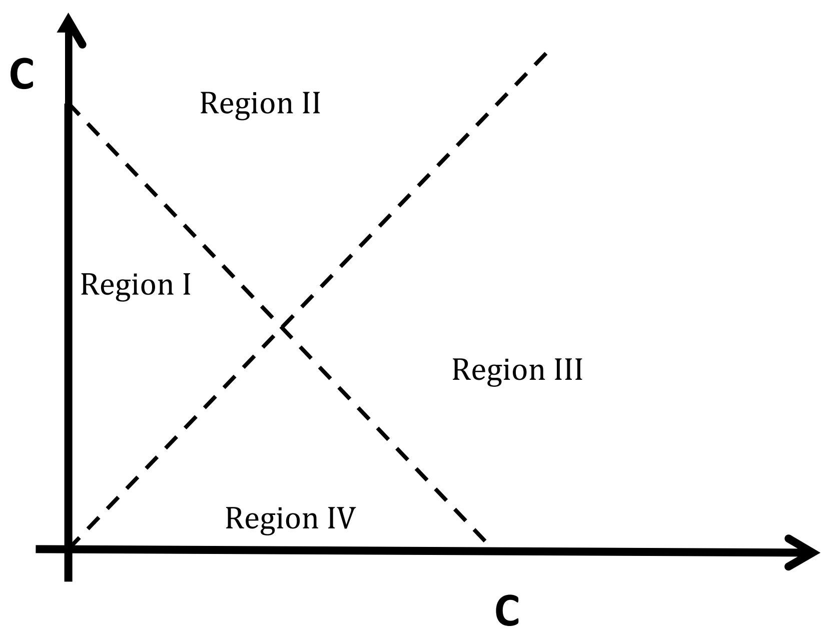
Congestion Control

Harry Bovik is building a new type of router. The router uses three explicit feedback messages - DECREASE, STAY and INCREASE - to communicate with sources in the network. It uses these messages in the following ways:

- If the network is underutilized, the router sends an INCREASE message to all sources.
- If the network is over-utilized, the router sends a DECREASE to the sources with the highest allocation and STAY messages to all other sources.
- If the network is perfectly utilized, the router sends a DECREASE to sources with the highest allocations.

We will assume that the number of streams using the router is always fixed, feedback messages are never lost, and the round-trip times for all connections are the same. While TCP additive-increase/multiplicative-decrease (AIMD), Harry decides that sources in this network should use additive increase/*additive decrease* (AIAD). In this scheme, each source will increase its sending rate additively by a small amount in response to a INCREASE message, decrease additively by a small amount on a DECREASE message, and not adjust its sending rate on a STAY message. Harry claims that the system should still converge to fairness and efficiency.

1. Harry decides to use phase-plots to check his intuition for the two-user case. The figure below shows a simple phase plot. In the graph, the state of the system is represented by a point (x1, x2), where x1 is stream 1's current rate and x2 is stream 2's current rate. The total capacity of the link is C bits/s. On the figure, for each of the labelled regions, I, II, III, and IV, draw vectors indicating the direction in which the system will move after feedback from the router.



2. In each of the four regions, does the response to the router messages increase, reduce or keep fairness the same?
3. Does Harry's scheme converge to a fair allocation? Explain your answer.