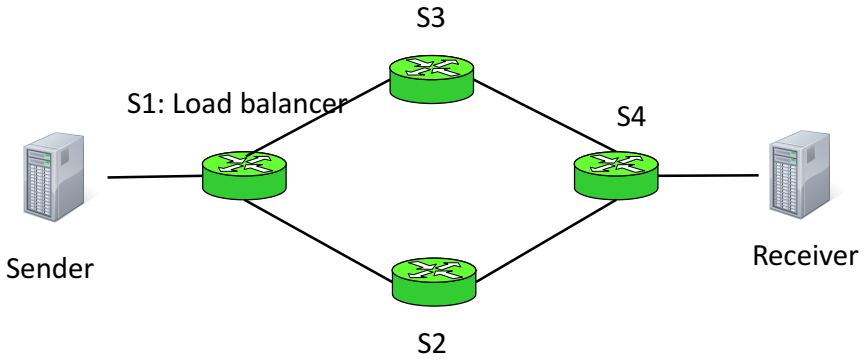
Homework Two: Programmable Networks

* Milestone 1: Build a topology for multipath routing

- **Task 1:** Building a topology with two servers and four switches in Mininet, where there are two alternative paths between the servers.



- **Task 2:** Write a P4 program that performs ECMP load balancing at the first hop (S1), and destination-based forwarding for all other hops (S2-S4). (You can use a special header to distinguish the first hop from other hops; first hop will remove this header after processing.)
- **Task 3:** Add monitoring capability to the P4 program, so that a switch can keep track of the number of bytes sent to each of its outgoing ports. The control plane should be able to issue queries to the data plane to collect statistics.

* Milestone 2: Understanding the limitations of ECMP

- **Task 1:** Generate random flows (as defined by the five tuples), with different sizes. and test how well ECMP load balances between the two paths (i.e., how many bytes are sent to the upper path vs. lower path). Report the total amount of traffic sent by the source, and the amount of traffic sent via each path.
- **Task 2:** Develop a per-packet load balancing mechanism in the P4 program, and test the load balance ratio again. Report the same set of numbers as Task 1.
- **Task 3:** Per-packet load balancing may result in out-of-order packet delivery. Quantify the amount of out-of-order packets per flow. *Notes: There are multiple ways of doing this; for instance, you could embed a special counter in the packet header as the packet is sent at the source, and then collect the sequence of packets at the destination. Suppose you have a sequence a1, a2, …, ak, then you*

can quantify the amount of reordering by computing the number of inversions in the sequence: https://leetcode.com/problems/global-and-local-inversions/

* Milestone 3: Implement flowlet switching (Only required for graduate students in the 536 version of the class)

- **Task 1:** Implement flowlet switching on S1; other switches still use destination-based forwarding to their only next hops.
- **Task 2:** Quantify the amount of out-of-order packet delivery per flow. Compare the findings with those in per-packet load balancing.

Homework submission: Please directly compress the working directory for your P4 programs, topology files, command files, and other files that are necessary to build your programs as a .tgz file. Provide a PDF file describing the results, and put them in the same tarball. In your PDF file, please include a) your name, b) your Rice NetID, and c) your student ID (that starts with 'S'), and of course, descriptions for each milestone and results. Submit via Canvas before the due date.

Due date: Feb 23. **Late policy:** -20% of the scores for each late day.