Project 5 - Multi Path TCP (MPTCP)

Goal

The goal of this project is to learn about a variant of TCP called Multipath TCP (MPTCP for short). We will do this by replicating a subset of the results of the original research paper that presented MPTCP. Multipath TCP allows a particular TCP flow to simultaneously send data across multiple paths to the receiver. This increases the connection's resilience to downed links across any particular path and allows for higher throughput by utilizing multiple network interfaces available on hosts.

For example, a cellphone could simultaneously send data via a MPTCP connection by starting a subflow over both the WiFi link and the cellular connection (3G/4G). If either signal deteriorates, the flow can survive. If both signals are good, MPTCP will take advantage of the combined bandwidth to improve overall performance.

Mininet is a particularly useful tool for this experiment as MPTCP is not widely deployed. Using Mininet, we can safely test MPTCP without causing issues to real network traffic or devices.

Be sure to read the master project 5 thread on Piazza for tips and tricks to working with this project.

Directions

1. Read the paper. You can also watch the conference presentation video.
2. Download and unzip the project code.

- `Navigate to the project code directory`
- `Make sure the files have the right permissions with chmod -R 777 .`

3. The provided `topo_wireless_handoff.py` builds the experimental topology in Figure 1a to perform a wireless handoff experiment. Running the topology with the following command, we will confirm that MPTCP works over multiple links simultaneously and can continue functioning in the presence of downed links. Now run the topology and generate a graph of the results:
   - `sudo ./mptcp_handoff.sh`

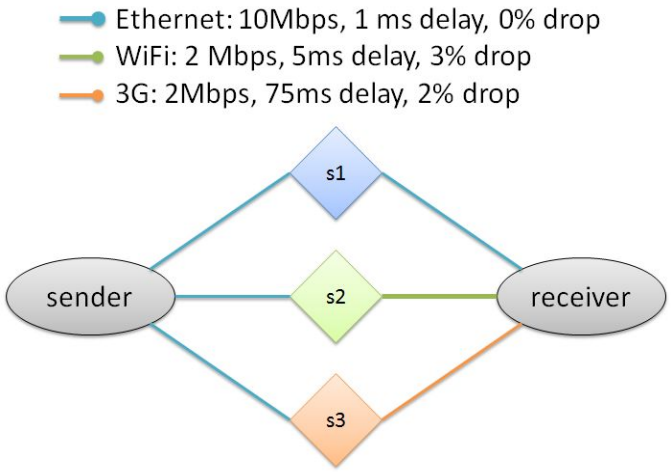
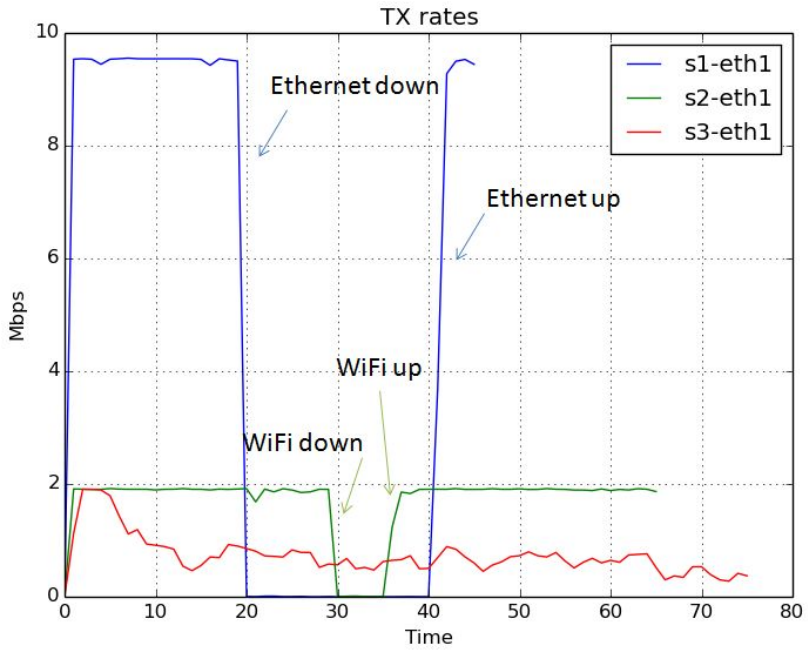


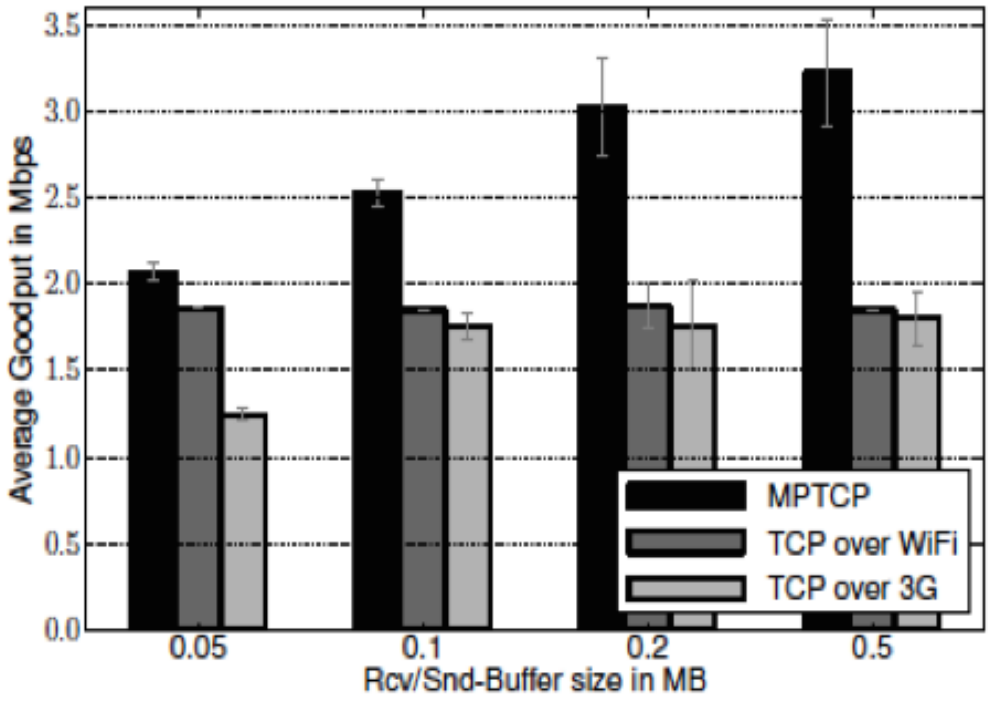
Figure 1a: Wireless Handoff Topology

4. Your results, saved in `handoff-results.png`, should be similar to the following graph, but might not be due to variations in virtualization and hardware. In this handoff test, you should notice both the Ethernet and WiFi links go down and then come back up. Throughout the experiment, the 3G graph continues despite the other downed links, indicating that the overall TCP connection

has survived the loss of the other two links. Note some interfaces may stop earlier than others - this is okay, as long as you see the down and up as in the sample graph.



5. Now that you've shown that MPTCP works over multiple links, you're ready to replicate a subset of the results in the original paper. You'll run the following topologies to approximate results from the following graph.



The first topology tests MPTCP throughput over a WiFi and 3G link. The second and third topologies test TCP throughput over a WiFi and 3G link respectively. For simplicity, we will measure throughput instead of goodput like the original paper.

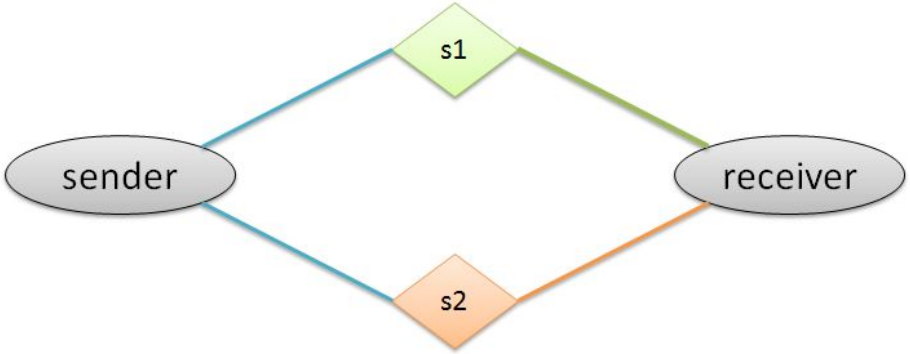


Figure 1b: MPTCP Performance Topology

Figure 1c: TCP Performance Topologies

To run the tests, execute the following command: `sudo ./mptcp_sweep.sh.` Expect it to take around 15 minutes to run.

6. The script runs the tests in the following chronological order: MPTCP WiFi and 3G, TCP WiFi, and TCP 3G. Each test will be repeated four times - once for each buffer size - 0.5 MB, 0.2 MB, 0.1 MB, and 0.05 MB. You will find folders labeled `mptcp` followed by a timestamp in the Project-5 directory, and within each of these folders a `rate.png` file with the throughput results. The average throughput for each of the three tests can be inferred by viewing the rate graphs and approximating the average value over the

course of the experiment. For the MPTCP graphs you will need to add the average WiFi and 3G throughput together to calculate the total average throughput for the MPTCP connection.

7. Finally, you will create a detailed yet concise (no longer than 3 pages with default font size, spacing and margins) report analyzing your results. Your analysis should include your rate graphs generated by the experiment, as well as a bar graph similar to the one from the paper (step 5) comparing the result of the three tests for each buffer size. Images do not count toward your three page limit. Your analysis should answer the following questions:
    - How well did each topology perform for each of the buffer sizes? (You can use a table or paragraph form, but should give specific results for each)
    - Which topology had the best performance for each buffer size?
    - Was there a significant increase in performance for the MPTCP topology vs. the topologies using single path TCP? How did this depend on the buffer size?
    - How do your results compare to the original paper?
    - Consider the deployment requirements raised in the paper. Based on your results only, is MPTCP worth implementing and deploying? Why or why not?

   Save your analysis as a PDF file, so it can be turned in for grading. An easy way to accomplish this is to compose your analysis in Google Docs, and download it as a PDF for turn-in.

What to turn in

You will turn in the following files on T-Square:

1. `Analysis.pdf` - A detailed yet concise analysis of your experimental results that you wrote during step 7. Ensure your analysis includes the rate graphs for all three topologies for the four buffer sizes, as well as a bar graph you generate to compare your experimental results to the paper's.

What you can (and cannot) share

Do not share the following files with your fellow students, on Piazza, or publicly:

1. `Analysis.pdf`

You may, and are highly encouraged to, share your interesting and or unique performance graphs. Keep in mind individual hardware will play a large role in your experimental results, so don't fret if your graphs look different from your fellow classmates. Feel free to discuss your opinions of the effectiveness of MPTCP on Piazza!

Grading

10 pts	Correct Submission	for turning in the correct files, with the correct names, and significant effort has been made towards completing the project per the instructions.

40 pts	Experimental Analysis	for your detailed, yet concise analysis of your results obtained in steps 5-6. Be sure to answer the questions specified and include the appropriate data/graphs in order to receive full credit. Be specific and avoid over-generalizing answers.