**1) Describe the parameters you use, e.g., length of time to transmit (with -t), number of parallel connections (with -P), and other parameters if you specify any. Note, only the number of parallel connections should vary, and all other parameters should be fixed.**

Parameters:

* Port (-p) = 5201 (occasionally 5202, 5203, or 5204, if 5201 failed). Reason for choice: arbitrary. Any port that would connect to the iperf server was sufficient.
* Length of time to transmit (-t) = 5. Reason for choice: Anything less than 4 was deemed an insufficient amount of time to bring out good results. Anything over 7 unnecessarily dragged out testing time. Thus, -t 5 was deemed a fair compromise between the two competing constraints.
* Parallel connections (-P) = [1, 7]. Reason for choice: originally, the window ran from one to twenty [1, 20] connections, and the data points for that window are included in Figure 2. However, after P=7, the results from different trials varied too widely to be of use (conjectures as to why this is the case are discussed in following questions). From observation, the window of parallel connections that show a clear trend runs from [1, 7] (see Figure 1).
* Trial runs = 3. Reason for choice: the iperf command for –P [1, 20] were run three times to ensure that the observed trends were significant rather than one-time flukes.

The iperf command was run with the above parameters, and three repetitive trials were done. The results can be seen in Figure 1.

**2) What's the number of parallel connections that give the highest aggregate bandwidth? What's the trend of aggregate bandwidth as the number of parallel connections increases?**

Based on Figure 1, the number of parallel connections that results in the **highest aggregate bandwidth is P = 4, 5.**

The trend of aggregate bandwidth as the number of parallel connections increases was observed as follows: the aggregate bandwidth increases steadily with parallel connections from P=[1, 3]. The aggregate bandwidth plateaus from around P=[3, 6], and it decreases at P=[7, 8]. (See Figure 1.)

For any P > 8, the aggregate bandwidth trend varies widely across the three trials (see Figure 2). In trial 1, aggregate bandwidth decreases notably after P=8. In trial 2, aggregate bandwidth wildly fluctuates with increasing number of parallel connections. In trial 3, aggregate bandwidth decreases slightly (but not to the degree observed in trial 1) and fluctuates slightly (but not to the degree observed in trial 2).

**3) Briefly explain the possible reasons behind what you observe. For instance, if aggregate bandwidth increases with more parallel connections at the beginning, then what's the mathematical formula that may explain this? And if aggregate bandwidth stops increasing or even decreases a bit later on, what might be the possible causes?**



Figure 1. Aggregate Bandwidth vs. Number of Parallel Connections with maximum number of connections = 7, three repetitive trials.



Figure 2. Aggregate Bandwidth vs. Number of Parallel connections with –P maximum at 20, three repetitive trials.

**1) Describe the parameters you use, e.g., length of time to transmit (with -t), which servers you use (and where they are located), and other parameters if you specify any. Note, only the server names should vary, and all other parameters should be fixed.**

Parameters:

* Port (-p) = 5201 (occasionally 5202, 5203, or 5204, if 5201 failed). Reason for choice: arbitrary. Any port that would connect to the iperf server was sufficient.
* Length of time to transmit (-t) = 5. Reason for choice: Anything less than 4 was deemed an insufficient amount of time to bring out good results. Anything over 7 unnecessarily dragged out testing time. Thus, -t 5 was deemed a fair compromise between the two competing constraints.
* Parallel connections (-P) = 1. Reason for choice: no need for parallelism, one connection is sufficient.
* Servers chosen: see Figure 3. Reason for choice: every single server on the iperf servers page that would accept pings were used. I wanted as many data points as possible for accuracy.

|  |  |  |  |
| --- | --- | --- | --- |
| Bandwidth (Mbits / sec) | Avg RTT (ms) | Server | Country |
| 101 | 68.708 | iperf.scottlinux.com | USA |
| 90.3 | 78.876 | bouygues.iperf.fr | France |
| 40.1 | 121.214 | iperf.volia.net | Ukraine |
| 35.7 | 165.251 | iperf.it-north.net | Kazakhstan |
| 8.01 | 298.303 | iperf.biznetnetworks.com | Indonesia |

**Figure 3. Chosen servers and the corresponding countries, noted with their bandwidth and average RTT.**

**2) What mathematical relationship should you expect to see between throughput and RTT? Why?**