

# Network Quality of Service Test Methodology for 5G

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## Background

5G wireless networks provide high bandwidth and low latency and accommodate many devices to connect and communicate simultaneously. Therefore, it makes it possible to operate robots to take on routine maintenance in the accelerator tunnel at Fermilab and ensure stable and reliable operation of the particle accelerator complex. This project mainly tests fundamental parameters of the 5G network and provides reference data for various possible application scenarios at Fermilab.

## Getting Familiar with the Accelerator Tunnel

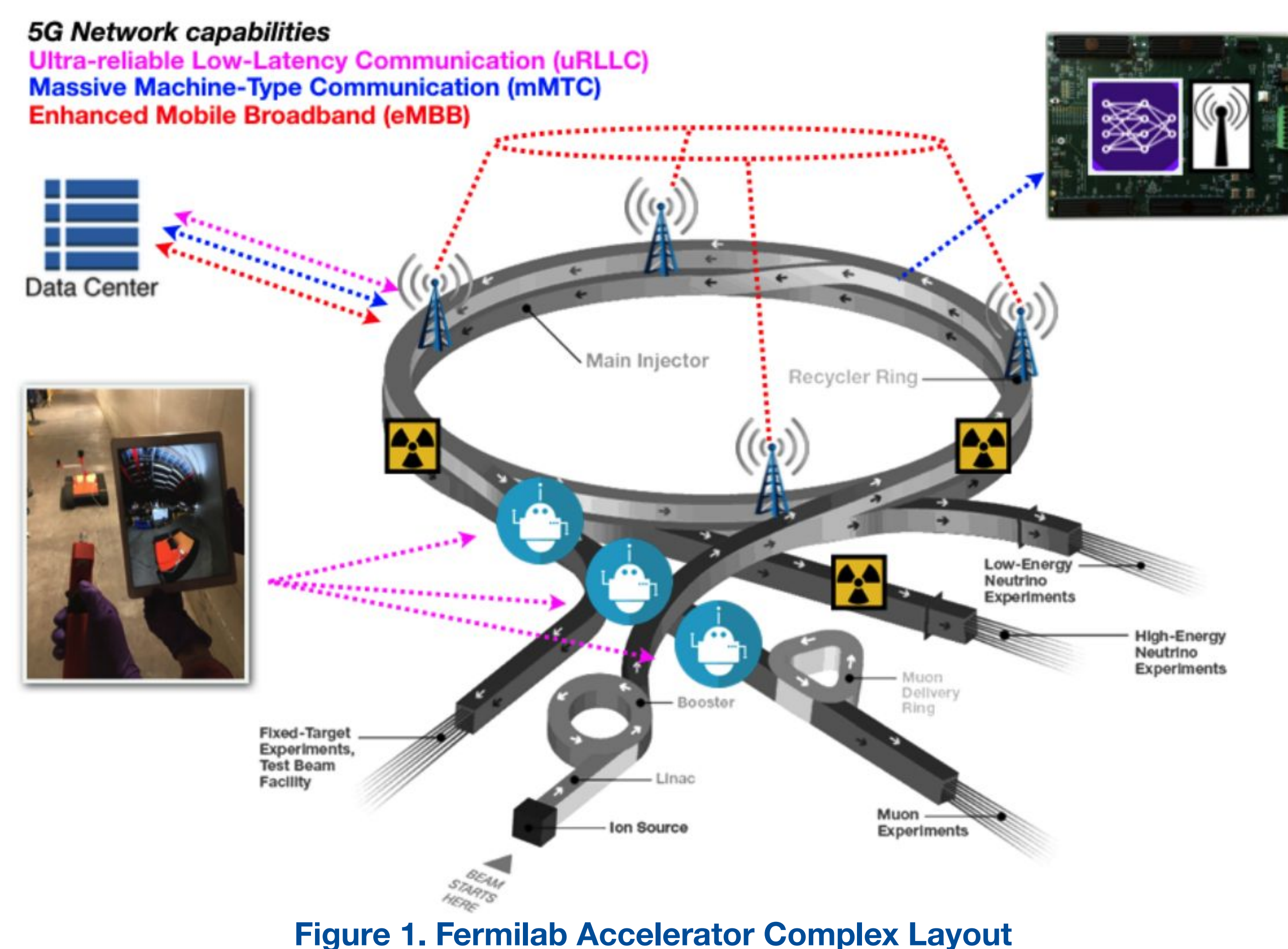


Figure 1. Fermilab Accelerator Complex Layout

## Testing Environment Setup

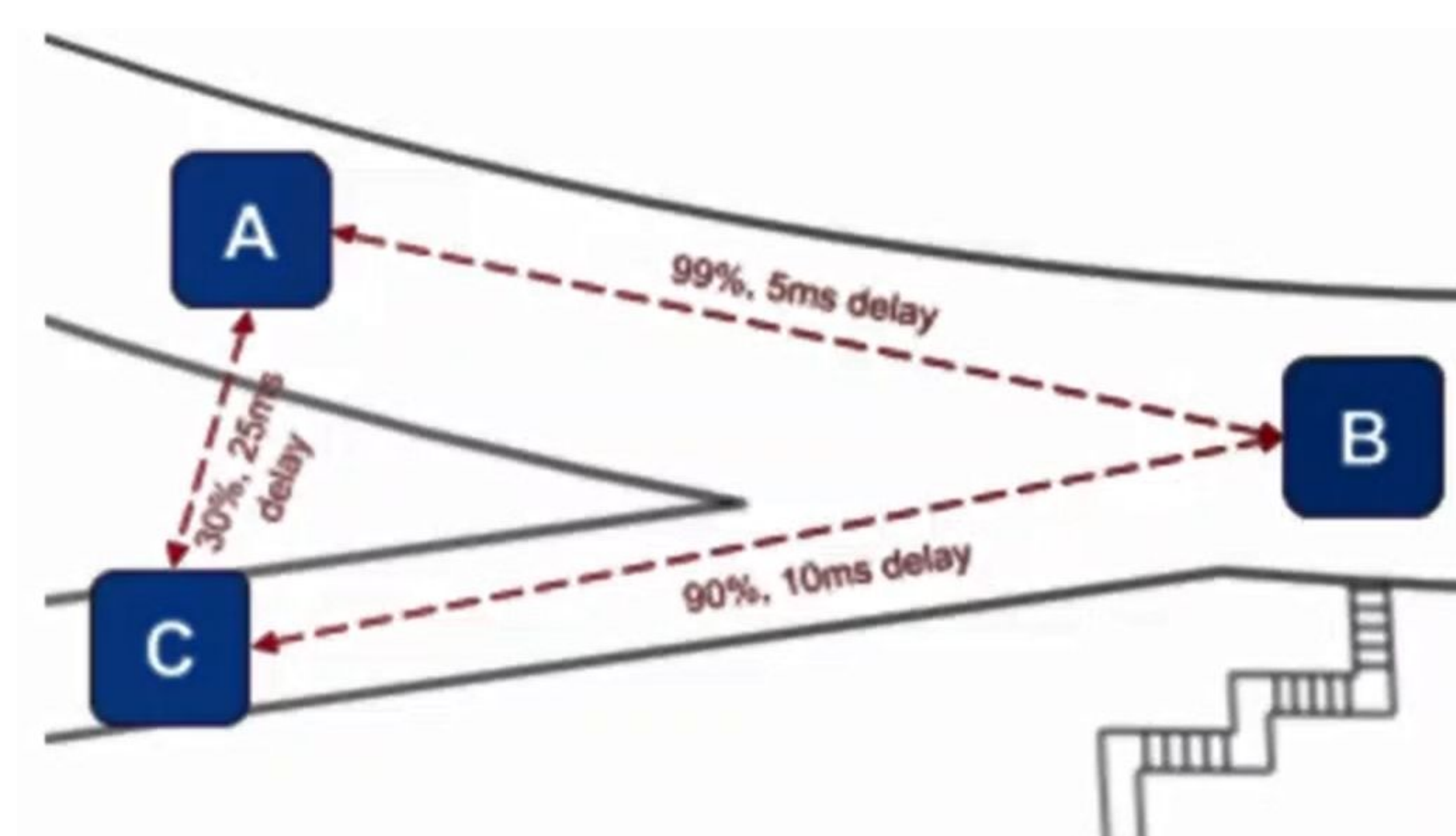


Figure 2. Point-to-point (decentralized) Testing Configuration

## Network QoS and Testing Metrics

- Throughput
- Latency
- Packet Loss
- Jitter

### Accelerator Tunnels:

- Straight and Curved
- Signal interference
  - High Radiation
  - Adjacent RF Cavities
  - High Magnetic Fields

## Testing Automation and Data Analysis

### Testing Configuration

```

1 {
2   "port": "5201",
3   "format": "Mbits",
4   "interval": 1,
5   "json": "true",
6   "udp": "false",
7   "server": "true",
8   "daemon": "true",
9   "pidfile": "pid.txt",
10  "oneoff": "true",
11  "servlog": "ser_log.txt",
12  "servip": "192.168.1.15",
13  "time": 5,
14  "timeout": 100,
15  "clilog": "cli_log.json"
16 }

```

Figure 3. Testing Configuration File

### Test Result

```

Time: 1.005794
Throughput: 3867.148288
Time: 1.0024399999999998
Throughput: 12785.287168
Time: 1.0057840000000002
Throughput: 3073.376256
Time: 0.987304
Throughput: 3282.04288
Time: 1.0111869999999996
Throughput: 6541.017088

iPerf3 exited with code 0
Testing was successful!

```

```

iPerf3 exited with code 1
Testing was failed for the error -
unable to connect to server: Connec
tion timed out

```

Figure 5. Successful Test and Failed Test

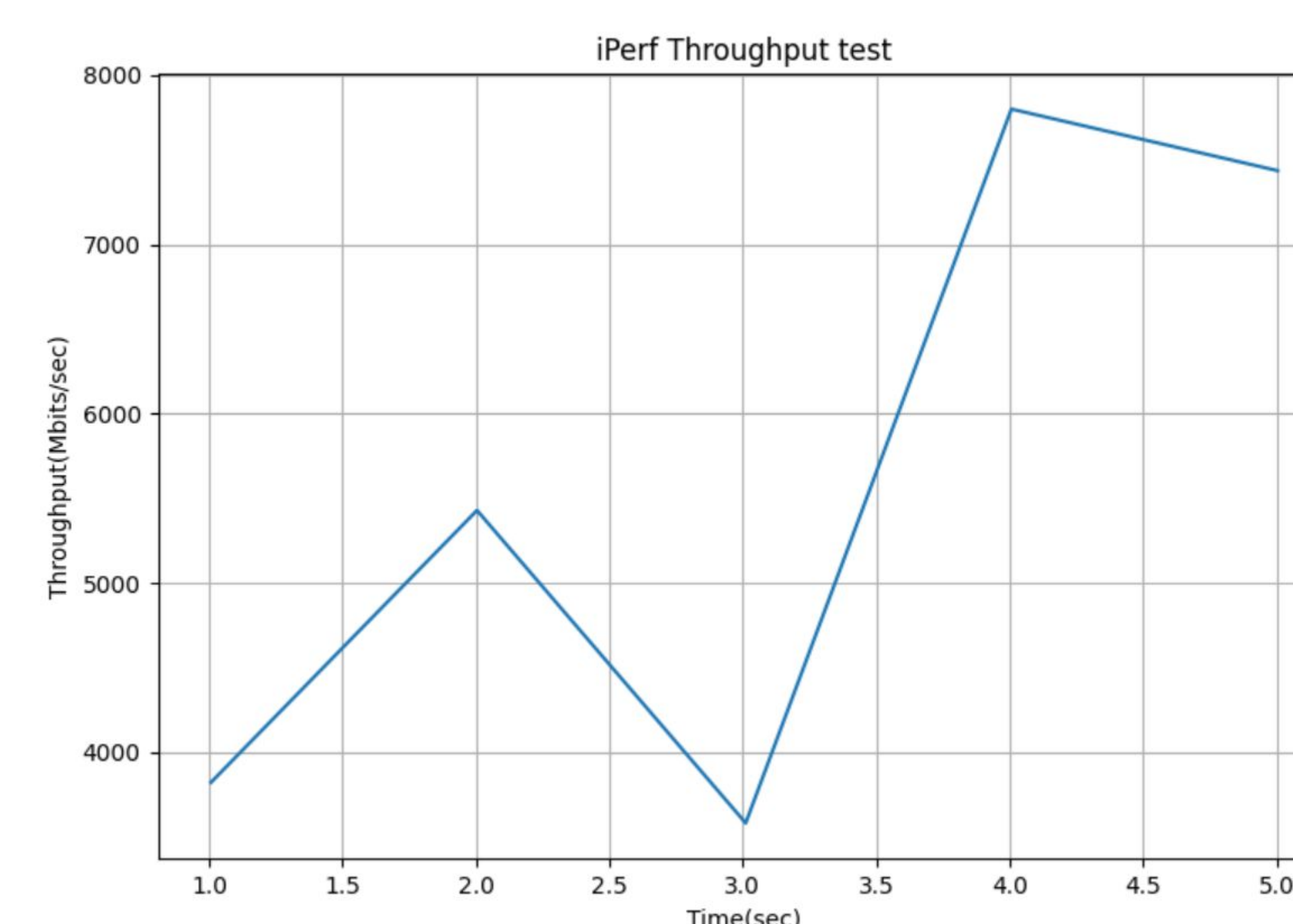


Figure 6. Test Result - Throughput

### Python Code

```

1 import os
2 import json
3 import matplotlib.pyplot as plt
4
5 # Read test Configuration and Run iPerf Test
6
7 # Read user config file for iPerf config
8 f1 = open('config.json')
9 data1 = json.load(f1)
10 f1.close()
11
12 # Run iPerf with user config, and Output iPerf data to file
13 exit_code = os.system(f"iperf3 -c {data1['servip']} -i {data1['interval']}\
14 -t {data1['time']} --json > {data1['clilog']}")
15
16 # Parse iPerf exit code and output file
17 f2 = open(data1['clilog'])
18 data2 = json.load(f2)
19 data2 = json.loads("{}".format(f2.read().replace('\n', ',')))
20 f2.close()
21
22 # Read test Output and Plot data into a Graph
23
24 #Plot iPerf output data in a graph
25 data_time = []
26 data_bits = []
27 for run in data2:
28   for interval in run['intervals']:
29     test_end = interval['streams'][0]['end']
30     test_start = interval['streams'][0]['start']
31     test_time = test_end - test_start
32     test_bits = (interval['streams'][0]['bytes'])* 8 / 10**6
33     print("Time: ", test_time)
34     print("Throughput: ", test_bits)
35     data_time.append(test_end)
36     data_bits.append(test_bits / test_time)
37
38 #present result and graph
39 print(f"\niPerf3 exited with code {exit_code}")
40 if exit_code == 0:
41   print("\n Testing was successful!")
42
43   plt.title("iPerf Throughput test")
44   plt.plot(data_time, data_bits)
45   plt.xlabel('Time(sec)')
46   plt.ylabel('Throughput(Mbits/sec)')
47   plt.grid()
48   plt.show()
49 else:
50   error = data2[-1]['error']
51   print("Testing was failed for the", error)

```

Figure 4. Python Code

## Summary

So far, we have set up a test environment, created testing metrics, and been able to use iPerf to measure the parameters. From the ideal 5G network test data, 5G network can achieve the expected goals of the project. However, this target conclusion needs to be verified by actual 5G network testing.

## Future Work

- 60Ghz Wi-Fi network Setup
- Improve Metrics