**CIS 549 Project 4 Report**

**Gordon Finn & Paul DeSanctis**

**Question #2**

Each subframe is downloading to 3 UEs per TTI, indicating the PRBs are shared evenly amongst the 3 UEs. There are 32 PRBs available, so this a 5.76MHz network (32x180K). The transmit blocks are consistently 2961 Bytes, so a 2 MB file downloading to 3 UEs would take (2048000/2961\*3=2075 TTI, i.e., roughly 2.1 seconds) and we do observe 2160 TTIs in the DLMacStat.dat file.

First 30 rows of DlMacStat.dat file:

% time cellId IMSI frame sframe RNTI mcsTb1 sizeTb1 mcsTb2 sizeTb2 Nprb

1.042 1 3 105 3 1 28 2961 0 0 32

1.042 1 1 105 3 2 28 2961 0 0 32

1.042 1 2 105 3 3 28 2961 0 0 32

1.139 1 1 114 10 2 28 2961 0 0 32

1.139 1 2 114 10 3 28 2961 0 0 32

1.139 1 3 114 10 1 28 2961 0 0 32

1.236 1 2 124 7 3 28 2961 0 0 32

1.236 1 3 124 7 1 28 2961 0 0 32

1.236 1 1 124 7 2 28 2961 0 0 32

1.333 1 3 134 4 1 28 2961 0 0 32

1.333 1 1 134 4 2 28 2961 0 0 32

1.333 1 2 134 4 3 28 2961 0 0 32

1.334 1 1 134 5 2 28 2961 0 0 32

1.334 1 2 134 5 3 28 2961 0 0 32

1.334 1 3 134 5 1 28 2961 0 0 32

1.43 1 2 144 1 3 28 2961 0 0 32

1.43 1 3 144 1 1 28 2961 0 0 32

1.43 1 1 144 1 2 28 2961 0 0 32

1.431 1 3 144 2 1 28 2961 0 0 32

1.431 1 1 144 2 2 28 2961 0 0 32

1.431 1 2 144 2 3 28 2961 0 0 32

1.527 1 1 153 8 2 28 2961 0 0 32

1.527 1 2 153 8 3 28 2961 0 0 32

1.527 1 3 153 8 1 28 2961 0 0 32

1.528 1 2 153 9 3 28 2961 0 0 32

1.528 1 3 153 9 1 28 2961 0 0 32

1.528 1 1 153 9 2 28 2961 0 0 32

1.529 1 3 153 10 1 28 2961 0 0 32

1.529 1 1 153 10 2 28 2961 0 0 32

1.529 1 2 153 10 3 28 2961 0 0 32

**Question #3**

Throughput charts (LTE and Wi-Fi)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| RTT(ms) | RWND (Bytes) | MCS | 1 UE | | 3 UE | | | |
| Per UE | | Per UE | | System level | |
| LTE-TCP | | LTE-TCP | | LTE-TCP | |
| Peak (Mbps) | Avg (Mbps) | Peak (Mbps) | Avg (Mbps) | Peak (Mbps) | Avg (Mbps) |
| 30 ms | 64000 | Default | 14.11 | 10.00 | 11.20 | 10.00 | 33.60 | 30.00 |
| 200 ms | 64000 | Default | 4.93 | 1.95 | 4.93 | 1.92 | 14.78 | 5.75 |
| 30 ms | 1024000 | Default | 72.58 | 47.05 | 22.85 | 20.00 | 68.54 | 59.99 |
| 200 ms | 1024000 | Default | 72.46 | 22.85 | 22.85 | 16.00 | 68.54 | 47.99 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| RTT(ms) | RWND (Bytes) | MCS | 1 UE | | 3 UE | | | |
| Per UE | | Per UE | | System level | |
| Wi-Fi TCP | | Wi-Fi TCP | | Wi-Fi TCP | |
| Peak (Mbps) | Avg (Mbps) | Peak (Mbps) | Avg (Mbps) | Peak (Mbps) | Avg (Mbps) |
| 30 ms | 64000 | HtMcs1 | 14.67 | 11.11 | 12.64 | 7.12 | 24.08 | 21.23 |
| 200 ms | 64000 | HtMcs1 | 5.04 | 2.48 | 5.04 | 2.63 | 13.66 | 6.94 |
| 30 ms | 1024000 | HtMcs1 | 23.97 | 21.04 | 23.86 | 13.70 | 23.86 | 20.68 |
| 200 ms | 1024000 | HtMcs1 | 23.86 | 16.32 | 23.97 | 11.34 | 23.97 | 16.78 |
| 30 ms | 64000 | HtMcs7 | 16.80 | 15.38 | 16.58 | 13.79 | 46.59 | 41.36 |
| 200 ms | 64000 | HtMcs7 | 5.04 | 4.59 | 5.04 | 3.00 | 15.12 | 7.73 |
| 30 ms | 1024000 | HtMcs7 | 70.34 | 25.80 | 114.46 | 61.76 | 114.46 | 92.27 |
| 200 ms | 1024000 | HtMcs7 | 113.57 | 72.70 | 81.76 | 27.32 | 114.13 | 66.66 |

TCP Analysis with 1UE (LTE and Wi-Fi):

**A screenshot of a cell phone

Description automatically generated**

A screenshot of a cell phone

Description automatically generated

We observe best throughput with Wi-Fi (~125Mbps) vs LTE (~75Mbps). With LTE, we observe similar throughput with 30ms and 200ms RTT with the same 1Mb window size. The smaller 64K window size had much lower throughput with LTE and Wi-Fi.

TCP Analysis with 3UEs (LTE and Wi-Fi)

A screenshot of a cell phone

Description automatically generated

A picture containing screenshot, map

Description automatically generated

Again, with 3 UEs, Wif-Fi outperforms LTE throughput (~125 vs ~75 Mbps). With LTE, throughput was identical with the 1Mb window size and we see the delayed start with 200ms RTT vs. 30ms RTT for both FTE and Wi-Fi.

TCP Analysis for single UE with 3UEs (LTE and Wi-Fi)

UE1

A screenshot of a social media post

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A screenshot of a social media post

Description automatically generated

UE2

A screenshot of a social media post

Description automatically generated

A screenshot of a social media post

Description automatically generated

UE3

**A screenshot of a social media post

Description automatically generated**

A screenshot of a cell phone

Description automatically generated

The 3UEs have similar throughputs with LTE (~23Mbs) as do the 3 UEs with Wi-Fi. With LTE, the individual UEs look almost identical, indicating they are getting roughly the same amount of throughput per UE.

**Question #4**

|  |  |  |  |
| --- | --- | --- | --- |
| RTT | MCS | 1 UE | |
| System Level | |
| LTE-UDP | |
| Peak (Mbps) | Avg (Mbps) |
| 30 ms | Default | 73.70 | 73.70 |
| 200 ms | Default | 73.70 | 73.70 |

|  |  |  |  |
| --- | --- | --- | --- |
| RTT | MCS | 1 UE | |
| System Level | |
| Wi-Fi UDP | |
| Peak (Mbps) | Avg (Mbps) |
| 30 ms | HtMcs1 | 25.20 | 25.09 |
| 200 ms | HtMcs1 | 25.09 | 25.09 |
| 30 ms | HtMcs7 | 121.97 | 121.73 |
| 200 ms | HtMcs7 | 121.97 | 121.73 |

UDP Analysis LTE and WiFi

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LTE throughput (~75Mbps) is roughly in between Wi-Fi MCS1 (~25Mps) and MCS7 (~121Mbps) for UDP.