**AMuSe: An Agile Multipath TCP Scheduler for Dual-Band 802.11ad/ac Wireless LANs**

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**60 GHz (802.11ad)**
- 2.16 GHz WIDE CHANNEL
- 4.6 Gbps
- SHORT RANGE
- VULNERABLE TO BLOCKAGE & MOBILITY

**5 GHz (802.11ac)**
- 80 MHz WIDE CHANNEL
- 1.3 Gbps
- RESILIENT TO BLOCKAGE & MOBILITY

**APPLICATION**
- send queue
- reinject queue

**PACKET SCHEDULER**
- (assign segments to flows)
- A: ROUND ROBIN
- B: RTT (DEFAULT)

**CONGESTION CONTROL**
- 802.11ad cwnd
- 802.11ac cwnd
- A: DECOUPLED
- B: COUPLED

**MULTIPATH-TCP (MPTCP)**

**CONGESTION CONTROL**

**MAXIMIZING THROUGHPUT**

\[
\text{Ratio}_{\text{optimal}} = \frac{P_{\text{ac}}}{T_{\text{ac}}} = 0.29
\]

**PERFORMANCE ISSUES & CHALLENGES**

**PROBLEM**
- TCP sender throttled

**SOLUTION**
- Adjust packet assignment ratio dynamically
- Use TCP’s internal rate estimation
- Up to 2.5x gain

**PROBLEM**
- TCP sender unaware of SCAN

**SOLUTION**
- Uplink: Deactivate the scanning interface
- Downlink: Use MPTCP MP_PRIO flag to signal the other end
- Up to 2.2x gain

**PROBLEM**
- MPTCP scheduler and congestion control waiting on each other
- cwnd restored to 1/2 of original value

**SOLUTION**
- Uplink: Reset the flow’s pf flag
- Downlink: Send TCP_KEEPALIVE
- Restore cwnd to pre-loss value
- Reduce re-connection time by up to 10s

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