5G and congestion control considerations

IETF-121 ICCRG Nov 8 2024

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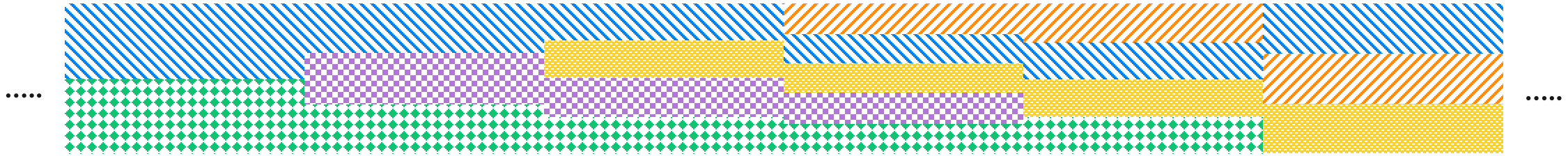
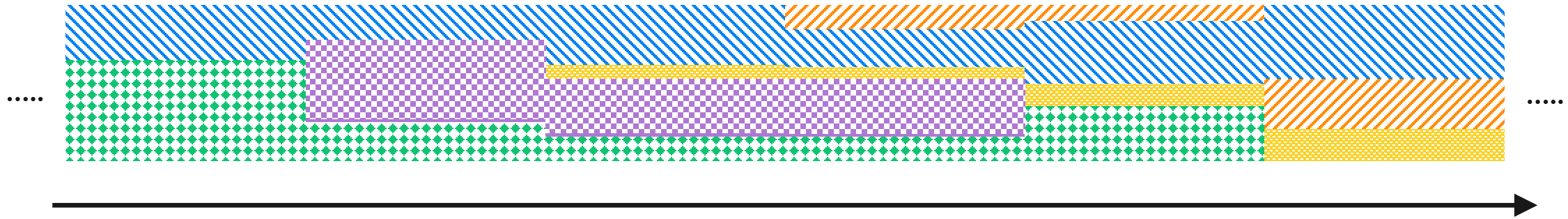
5G resource allocation

- Resource allocation in frequency and time (average)
  - End user applications may be bitrate limited
  - Resource allocation can drop in a few RTTs or in an instant when users enter (either new or HO from another cell)



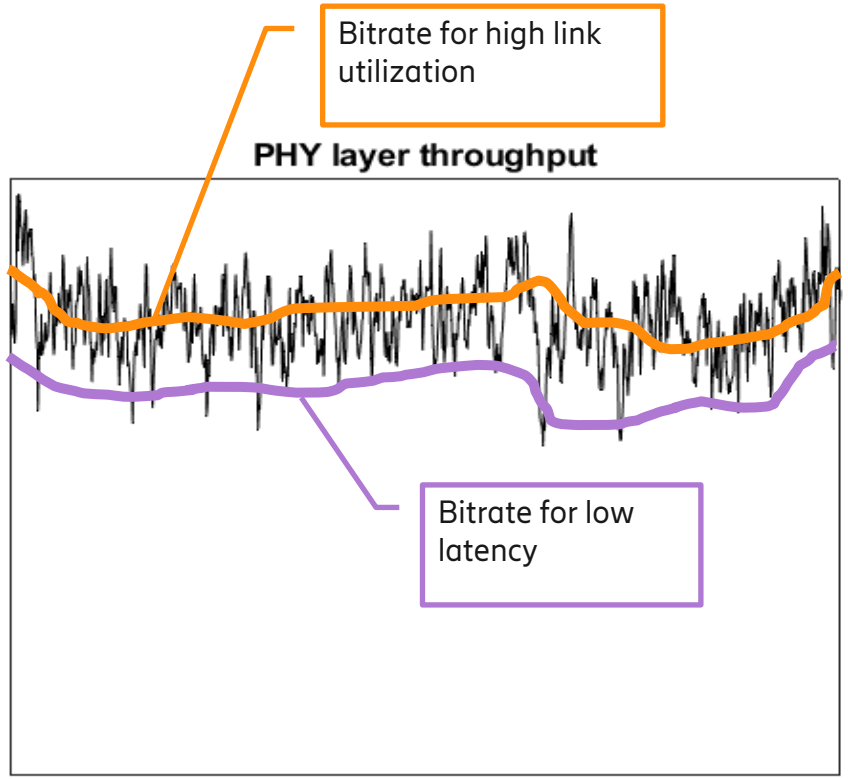
- Actual throughput (average)
  - Modulation and Coding Scheme (MCS) varies with channel quality, power limitation in uplink
  - Result, varying throughput… and there is generally no slack to temporarily steal from other users



5G throughput

- Throughput varies on a short time scale due to fast changes in channel quality
  - Throughput can drop quickly
  - Congestion control cannot track fast changes → headroom needed
  - Trade off between large network buffer, high link utilization **and** small network buffer, reduced link utilization, pick one

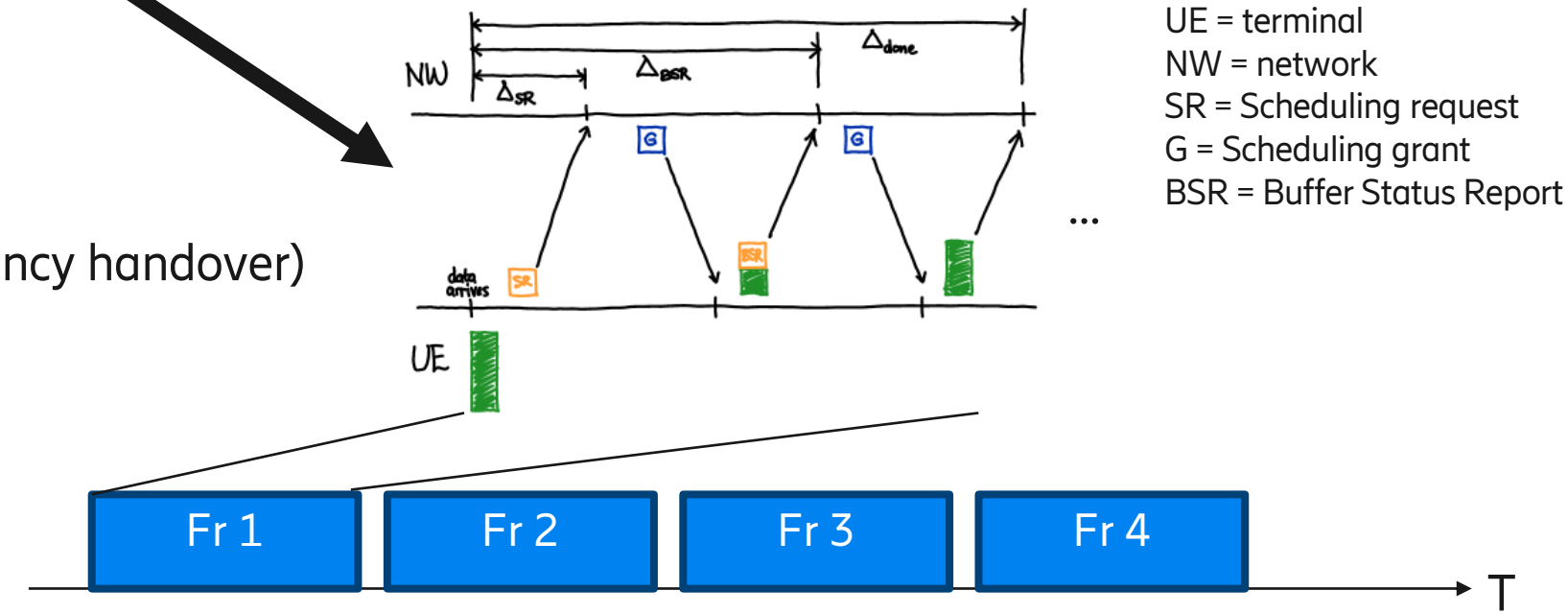
- Network buffering is not necessarily bad
  - Transport blocks are more easily filled with reduced control channel overhead
  - Addition of extra carriers may require a certain degree of buffer occupancy
  - Multi-user MIMO will be more efficient if there is some slack to pick the right occasion to schedule the UE



5G delay properties

- (Dynamic) uplink scheduling of intermittent data
  - Increased delay
  - Reduced link utilization
- Additional delay can occur due to
  - Handover
  - Retransmission (MAC, RLC)
  - Measurement gaps (inter frequency handover)

- Delay is a problematic congestion indicator!
  - Difficult to tell congestion related delay from other types of delay
- Good news is.. L4S!



UE = terminal
NW = network
SR = Scheduling request
G = Scheduling grant
BSR = Buffer Status Report