Lecture 9: Wireless link layer: error control and wrap-up

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Error control

- Error control in the form of link layer retransmissions required to recover from errors on the wireless channel

- Most of 802.11 (WiFi) uses Stop-and-Wait ARQ (automatic repeat request) protocol. That is, after sending a frame, the sender waits for a certain period of time for the link layer ACK. If no ACK is received, sender retransmits the frame multiple times. If the maximum retry limit is reached, sender abandons the frame and moves on.

- Successive retries are not always sent at the original bit rate. Different implementations of device drivers use different techniques, but usually, bit rate is dropped a notch every few retries, and the last retry of the frame is usually at the lowest bit rate.

- Do not forget that successive retries have longer and longer backoff times too (due to doubling of contention window)

Link layer overheads

- The various waiting times at the MAC layer, coupled with the time to wait for an ACK, lead to a much lower throughput at the link layer than what is offered by the physical layer.
- Please see your class notes or the reference on the class website for a guide on throughput calculations.
- Typically, when TCP is used, the TCP ACK is also a payload at the link layer, and has its own link layer ACK. Therefore, the overhead of a TCP segment includes the various MAC-level overheads of the data and for the TCP ACK as well.
- Therefore, for a typical bit rate like 54 Mbps, the best case TCP throughput is only about half the bit rate.

Frame Aggregation in 802.11n

- The new WiFi standard 802.11n proposes the frame aggregation technique to deal with the problem of MAC overheads

- Multiple link-layer frames (each with its own CRC) are aggregated and sent back-to-back as one large frame. Backoff for channel contention, waiting for link layer ACK, and all other such overhead-causing actions are performed only once for all the frames.

- A block ACK is used, where a bit map indicates which "sub-frames" in the aggregated frame have been delivered correctly.

- The block ACK for a certain frame can come after a subsequent frame also, to give the physical layer time to decode the frames. The block ACK covers a window of frames, and the window need not overlap exactly with the sent window and can lag behind a bit.

Error control in cellular networks

- Cellular data networks use a technique called Hybrid ARQ (HARQ), which combines channel coding and ARQ
- Two variants of HARQ
  - Incremental redundancy: puncture (remove) some coded parity bits from the original message in the first transmission. Send more parity bits as and when needed in subsequent retransmissions.
  - Chase combining: resend the original coded bits in the retransmission. However, combine both the original transmission and the retransmission to jointly decode the message
- HARQ techniques result in better performance, but are harder to implement

Wireless link-layer wrap-up

- Revise all the functions of the link-layer
    - Medium access
    - Link adaptation
    - Error control
- Walk through an example of a client-AP communication in WiFi, and a 3G/4G data communication in cellular networks from the perspective of the link layer.