Lecture 10: Link layer multicast

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Unicast and broadcast

- Usually, link layer is used to send data over a single hop between source and destination. This is called unicast.
- Broadcast mode is used when data has to be sent to all receivers in a local area network.
- For example, in WiFi, beacons of access points and other such management information is sent in a broadcast mode. For all other transmissions, unicast mode is used.
- When a link layer receives a packet, it checks the destination address in the link layer header, and processes the frame only if the destination address matches its own address or the broadcast address. Otherwise, it discards the frame.
- Wireless link layer operates over the inherently broadcast wireless medium. So nodes overhear a lot of packets for other nodes, decode them at the physical layer, and throw them out eventually.

Link layer multicast

- Consider applications where an AP wants to send the same file to multiple clients. Unicast flows to each client is wasteful because each client receives multiple copies of essentially the same data.
- Broadcast is not reliable since broadcast frames do not have link layer ACK.
- This lecture will discuss mechanisms for reliable link layer multicast. Sample applications are an AP wanting to send a video / large file to multiple clients simultaneously and in an efficient manner.
- There is no one accepted “best” way to do link layer multicast. So this lecture will discuss various ideas from many different research proposals.

Pseudo-broadcast

- One way to solve the problem is by a technique called pseudo broadcast. Link layers of multicast clients are configured to be in promiscuous mode (that is, they will process all packets, including unicast packets destined to other nodes).
- AP sends the multicast data as unicast packets to one of the clients (called the leader of the multicast group), and all the other clients reveive the data in promiscuous mode.

Mechanisms to ACK

- To be reliable, AP needs a mechanism to get ACK from multiple clients. We cannot use the link layer ACK, as multiple ACKs will collide.
- AP can periodically poll the clients to ask for ACKs.
- Leader of the group can be picked such that it has the worst link to AP. So leader can send the link-layer ACK (meaning most clients would have received the frame too), and the few other clients that did not get the frame can send a NACK (negative ACK)
- ACKing can be done once per batch of frames to amortize this overhead.
- Clients can use other techniques like CDMA to send ACKs in the same time slot.

What to retransmit?

- When the AP learns that some clients did not receive some subset of packets, it can choose to retransmit the union of all lost packets. However, this leads to lot of retransmissions.
- Another technique is that the AP can send some parity packets (generated using a block code over the original packets). This way, different clients can recover different lost packets from the same set of parity packets.
- For example, consider an AP that has sent two packets p1 and p2 to clients C1 and C2. If C1 got p1, and C2 got p2, the AP can simply retransmit p1+p2, and each client can recover the packet it is missing.
- This process of generating extra error correcting packets to recover from errors can happen at the source of the multicast flow (e.g., video server), or at the intermediate nodes (e.g., AP). This technique is called network coding in the latter case.

The idea of unequal error protection

- When multicast is used to send videos, we can further optimize the process by using knowledge of the application layer content.
- Some video frames (called I-frames) encode complete images of a frame. Subsequent frames (called P-frames and B-frames) encode only the difference from the previous (or next) frame.
- Receiving I-frames reliably is much more important than receiving P- or B-frames.
- Some link layer multicast techniques employ reliable mechanisms like ACKs only for I-frames, and deliver P- and B-frames unreliably using broadcast.
- This technique is called unequal error protection.

Cooperative relaying

- Sometimes, it may be beneficial for one of the clients to perform retransmissions of lost data to far away clients. This may lead to using higher data rate than when AP sends. Such a mechanism is called cooperative relaying.
- The relaying node can further retransmit just the original packets, or it can also send parity packets to benefit more clients with fewer retransmissions.
- This technique is more useful in multihop wireless networks (that we will study later in the course).

Other link layer mechanisms

- Adjusting contention window must be done carefully for multicast flows. If the multicast mechanism is using broadcast packets (which have no ACK), then the contention window will always be at its lowest value, and the multicast flow will lead to unfairness to other unicast flows.
- Rate adaptation is also a tricky problem for multicast. There is a tradeoff between sending at lower rates and reaching many clients vs. sending at higher rates and taking care of the far away clients using retransmissions.
- In general, multicast flows are limited by the rate of the farthest node in the network, and smarter mechanisms are needed to ensure that clients with good signal do not starve because of the slower clients.