

Recovering lost audio without a round trip: RTX vs FEC, Opus in-band FEC vs RED, the costs, and when to turn it on.

Retransmission vs FEC - two ways to fight loss

Retransmission (RTX)	Ask for the lost packet again	Exact recovery; costs 1 round trip - too slow on high-latency links
Forward error correction	Send redundancy ahead of time	No round trip; costs bitrate on EVERY packet, loss or not

The three FEC mechanisms (RFC 8854)

Separate FEC stream	Own RTP stream	High header overhead - NOT RECOMMENDED for audio
Redundant encoding (RED)	Same packet, RFC 2198	Low overhead; multi-frame protection - good for audio
Codec in-band FEC	Inside Opus payload	Lowest overhead; single-frame protection only

Opus in-band FEC vs RED vs DRED

Opus in-band FEC (LBRR)	Copies the PREVIOUS frame at low bitrate; protects 1 isolated loss; fails on 2-in-a-row.
RED (RFC 2198)	Wraps whole prior packets; 'distance 2' survives a 2-packet burst; ~doubles audio bitrate.
DRED (draft)	Neural redundancy: up to ~1 s of audio at ~1/50 bitrate; emerging fix for long bursts.

Numbers that matter

Opus FEC turns on only above ~1% loss; stereo Opus needs ~58 kbps before it produces LBRR (Mozilla, 2016).

Opus FEC correction is capped at 25% and its bitrate is subtracted from the target - raise bitrate to leave room.

RED roughly doubles audio: ~30 -> ~60 kbps + ~10 kbps header (distance 1); distance 2 is higher still.

At 60% loss: no RED = 60% samples concealed; distance 1 = 32%; distance 2 = 18% (webrtcHacks, 2020).

Negotiation & configuration

Opus FEC: receiver signals 'useinbandfec=1' (RFC 7587); sender enables FEC and sets expected loss.

RED: negotiate codec 'red' (a=rtpmap:111 red/48000/2) and place it BEFORE Opus in codec preferences.

Use VAD + DTX so redundancy is only sent during speech, not silence - keeps the doubled bitrate in check.

Keep it ADAPTIVE: send only as much FEC as the measured loss (from RTCP receiver reports) warrants.

Remember

- FEC sends redundancy ahead of time so loss is recovered with no round trip - unlike retransmission.
- FEC costs bitrate on every packet: it helps on lossy links and wastes bandwidth on clean ones.
- Opus in-band FEC protects only the single previous frame; RED distance 2 survives a 2-packet burst.
- On congestion-caused loss, adding FEC sends more data into a full pipe and makes loss worse.
- Match the tool to the loss pattern: random = Opus FEC; bursty = RED distance 2 (or DRED).