

The Streaming Pipeline — 9 Stages, End to End

Map of every stage between camera and screen, with typical protocol and latency contribution. 2026.

The nine stages

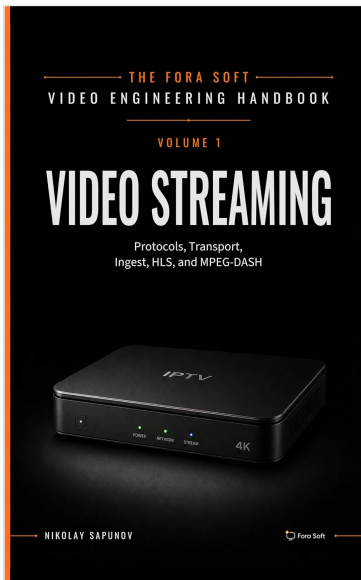
Stage	What it does	Latency added	Typical protocol	Common failure
1. Capture	Sensor → raw frame buffer	+16-33 ms	—	Bad focus / exposure
2. Encode	Compress with H.264/HEVC/AV1, 2 s GOP	+~200 ms	—	Wrong preset / GOP drift
3. Contribution	Ingest to cloud	+400 ms-4 s	WHIP / SRT / RTMP	Link drop / uplink starve
4. Transcode	Build bitrate ladder, 5 rungs	+~500 ms	—	Software on CPU vs GPU
5. Package	CMAF segments + manifest	+~300 ms	CMAF / fMP4	GOP-segment misalign
6. Origin	HTTP storage front	+20-100 ms	HTTPS	Window expiry / signed URL
7. CDN	Shield → mid-tier → edge	+10-500 ms	HTTPS / HTTP/3	Cache-key mismatch
8. Last-mile	Wi-Fi / mobile / fibre / satellite	+5-100 ms RTT	TCP / QUIC	Bufferbloat / handover
9. Player	Fetch, decode, paint	+2 000-18 000 ms	HLS / DASH / WebRTC	Default buffer too deep

Three typical configurations and their glass-to-glass total

Configuration	Segment / chunk	Total glass-to-glass	Typical use
Classic HLS	6 s seg, 18 s hold-back	18-30 s	OTT VOD-like live
Low-latency HLS / DASH	2 s seg, 200 ms chunks	2-5 s	Live sports, live shopping
WebRTC (WHEP / SFU)	no segments, paced RTP	0.2-0.5 s	Auctions, telemedicine

Key principle — the player buffer dominates HTTP-based latency

Apple HLS Authoring Spec requires the player buffer be at least 3 × segment duration before starting playback. A 6 s segment forces an 18 s floor; a 2 s segment with LL-HLS partials drops to 2-5 s; WebRTC removes the buffer entirely. Optimise the player config first if the goal is low-latency. The earlier stages combined rarely add more than a second.



GO DEEPER · VOLUME 2 OF 7

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From Network Protocols and Transport to Ingest, HLS, and MPEG-DASH

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This map lists the nine stages from capture to player with the latency, protocol and usual failure of each. Volume 2 covers those stages from encoder to network in depth: TCP and UDP behaviour, QUIC and HTTP/3, ingest over SRT and RTMP, and segment packaging for HLS, DASH and CMAF.

WHAT YOU WILL FIND INSIDE

- Glass-to-glass latency budget per stage
- CMAF segments, chunked transfer and LL-HLS partials
- Ingest and contribution: SRT, RIST, RTMP, WHIP
- Last-mile behaviour: congestion, loss and QUIC

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