

□□	□□	□□	□□□□
OpenGL 3.3+	C++	GPU □□□□□ YUV □□□□ Shader □□□□□	□□□□□ UV □□□□□□□□ texture2D □□ Y/U/V □□□□□□ RGB
std::thread / std::mutex / std::condition_variable	C++	□□□□□□□□□□ □□□□□□□□□□	□ std::queue<AVPacket*> + □□□□□□□□□□ □□□□
QML	QML	□□□ “□□ /□□ ”□□ + FPS □□	□□ Q_PROPERTY □□ fps □□□□□□□□

□ □□□ □ 1080p MP4 □□□□□ 60 FPS □ valgrind / AddressSanitizer □□□□ CPU □□ <15%
□□□□□

□□ W2□□□ SRT/UDP□□□□□ AVSync

□□	□□	□□	□□□□
FFmpeg SRT □□□□ □ libsrt	C++	□□□□ I/O □□□□□□□□	FFmpeg □□□□ srt:// □□□□ srt_create_socket + avio_alloc_context □□□□□□□□
SRTO_LATENCY / SRTO_TSBPDDELAY	C++	□□ SRT □□□□□□□□	□□ latency=120 □□□□□□□□□□ TSBPD □ Time-Sender-Based Packet Delivery □□□
□□□□□	C++	□□□□□□□□□□ □□□□	audio_clock = sample_pos / sample_rate □ video_delay = video_pts - audio_clock
□□□□ /□□□	C++	□□ video_delay □□□□□	delay > 40ms □□□ delay < -30ms □□□□□□□□ std::this_thread::sleep_until □□□□
QAudioSink (Qt6) □ PortAudio	C++	□□□□□□□□□□ □□	□□□□□□□□ audio_clock □□□□□□□□□□ □□□□
QML	QML	□□□□□□□□□□ □□□□	□□ latency_ms □□ sync_status □□□ UI □□□□

□ □□□□ □□□□ 1v1 □□□□□□□□ ≤200ms□□□□□□□ ≤±20ms
□□□□□□□□□□

W3 Fallback + JitterBuffer

Library	Language	Category	Details
AVHWDDeviceContext / AVHWFramesContext	C++	VA-API/DXVA2/VideoToolbox	av_hwdevice_ctx_create → AVCodecContext → AVERROR(EAGAIN)
PBO (Pixel Buffer Object) / EGLImageKHR	C++	GPU OpenGL	glGenBuffers + glMapBufferRange → glTexImage2D CPU-GPU Linux EGLImage
Jitter Buffer	C++	RTT/	jitter = max(inter_arrival) - min(inter_arrival) >10% + <3%
PLC (Packet Loss Concealment)	C++		" " "
tc qdisc (Linux) / Clumsy (Win)			tc qdisc add dev eth0 root netem loss 15% delay 50ms 20ms
perf / RenderDoc / nvidia-smi		CPU GPU	perf record -g ./app → perf report RenderDoc
QML	QML	FPS JitterBuffer	ChartView Canvas C++

PDF/Markdown 15% <2% CPU <8% PBO glReadPixels 72h <3%

W4 QML + /Profiler

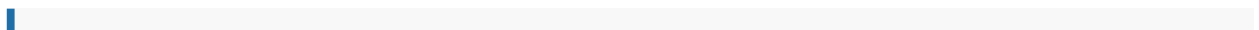
Library	Language	Category	Details
QQuickFramebufferObject / QSGTexture	C++	OpenGL QML	createRenderer() Renderer render() FBO QQuickPaintedItem

QStateMachine (Qt6)	C++	IDLE → CONNECTING → STREAMING → RECONNECTING → ERROR	/ if-else
spdlog QtLogging	C++	ID	SPDLOG_INFO("decode", "pts={ } delay={ }ms", pts, delay)
CMake + vcpkg / Conan		-O3 -march=native	FFmpeg::avformat Modern CMake Target
QML	QML		CustomButton Qt.binding()
draw.io / PlantUML			

Demo + + perf/RenderDoc + 5



	C++	QML	
(SRT/UDP)			avio libsrtp
/ (FFmpeg)			C++
(AVSync)			+ /
Fallback			AVHWDDeviceContext
(PBO/EGL)			OpenGL + QQuickFramebufferObject
Jitter Buffer / PLC			+
/ /			QStateMachine + spdlog
UI / /			QML Q_PROPERTY
	△ C++ QML		QQuickItem C++



```

“C++ + QML AVHWDDeviceContext Ffmpeg
Fallback PBO GPU OpenGL
QQuickFramebufferObject QML CPU-GPU
PTS /
±15ms Jitter Buffer RTT
PLC 15% <2%
spdlog perf/RenderDoc ≤450ms 1080p@30fps
CPU <7% 72h <3% ”

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QtMultimedia Ffmpeg API
MP4 HLS DXVA2 NVDEC
YUV RGB OpenGL DirectX
HLS
C

```

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#2
13 2026 15:50:23
18 2026 15:28:17

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