

Internet System

Multimedia Networking

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Multimedia networking applications

- streaming stored audio and video
- streaming live audio and video
- real-time interactive audio and video

- delay sensitive
- loss-tolerant

Multimedia networking applications

- streaming stored audio and video

stored media



video server rack



- streaming
- continuous playout

Multimedia networking applications

- streaming live audio and video

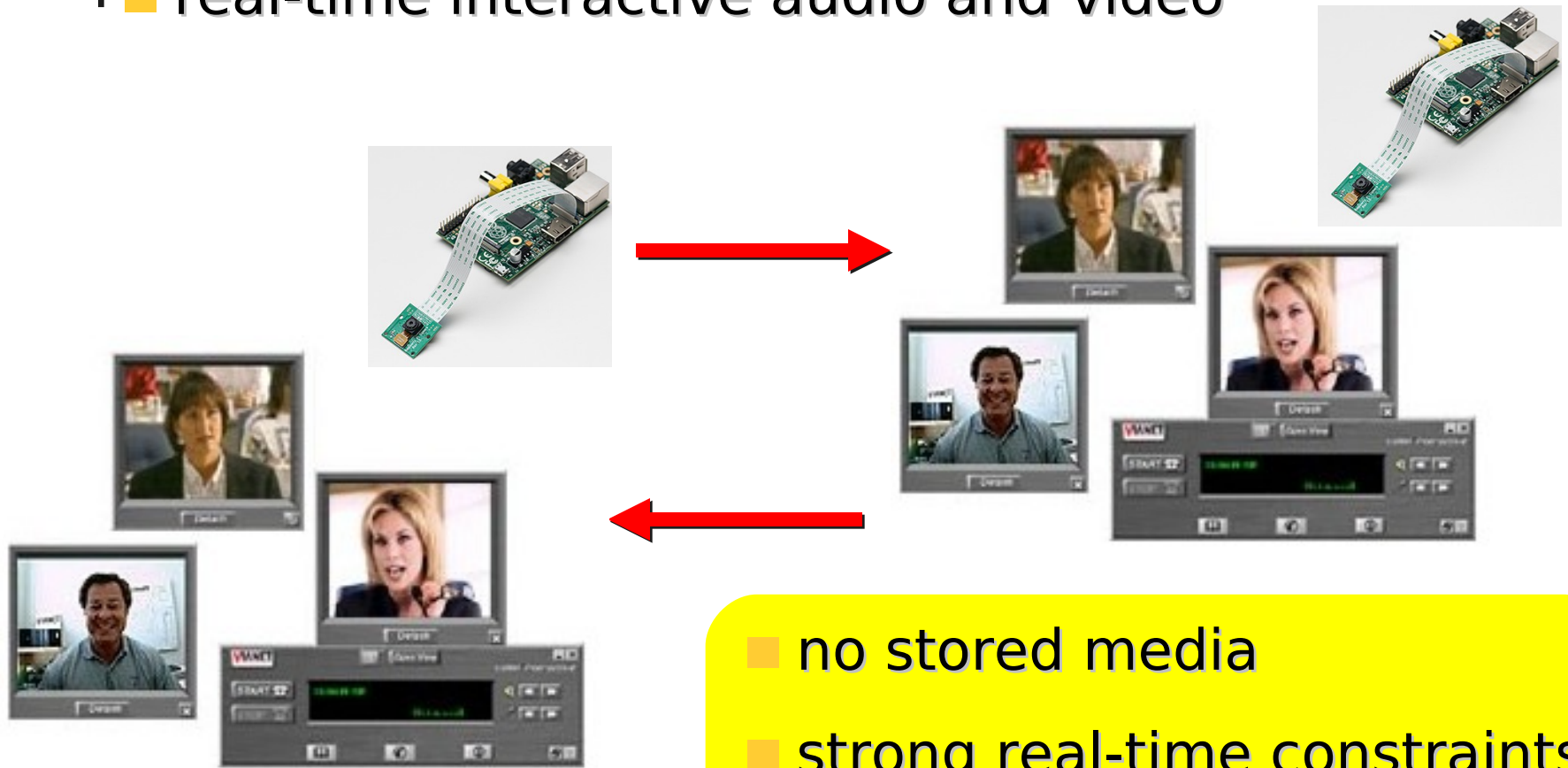


- media not stored
 - multiple streams
- broadcasting



Multimedia networking applications

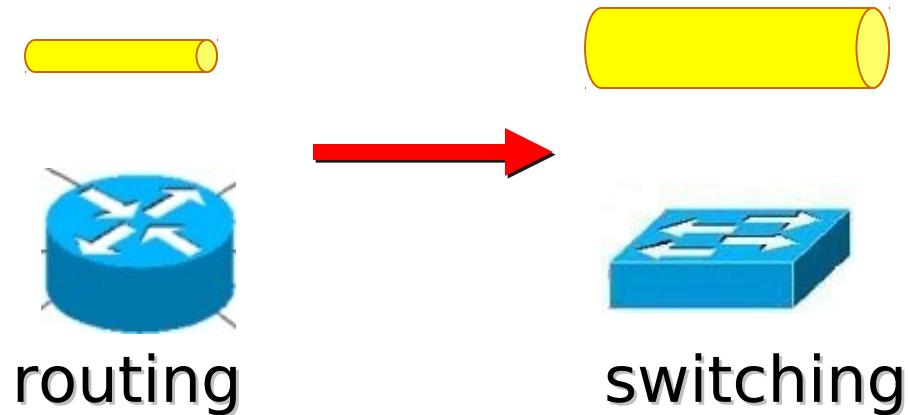
real-time interactive audio and video



- no stored media
- strong real-time constraints
- multicasting

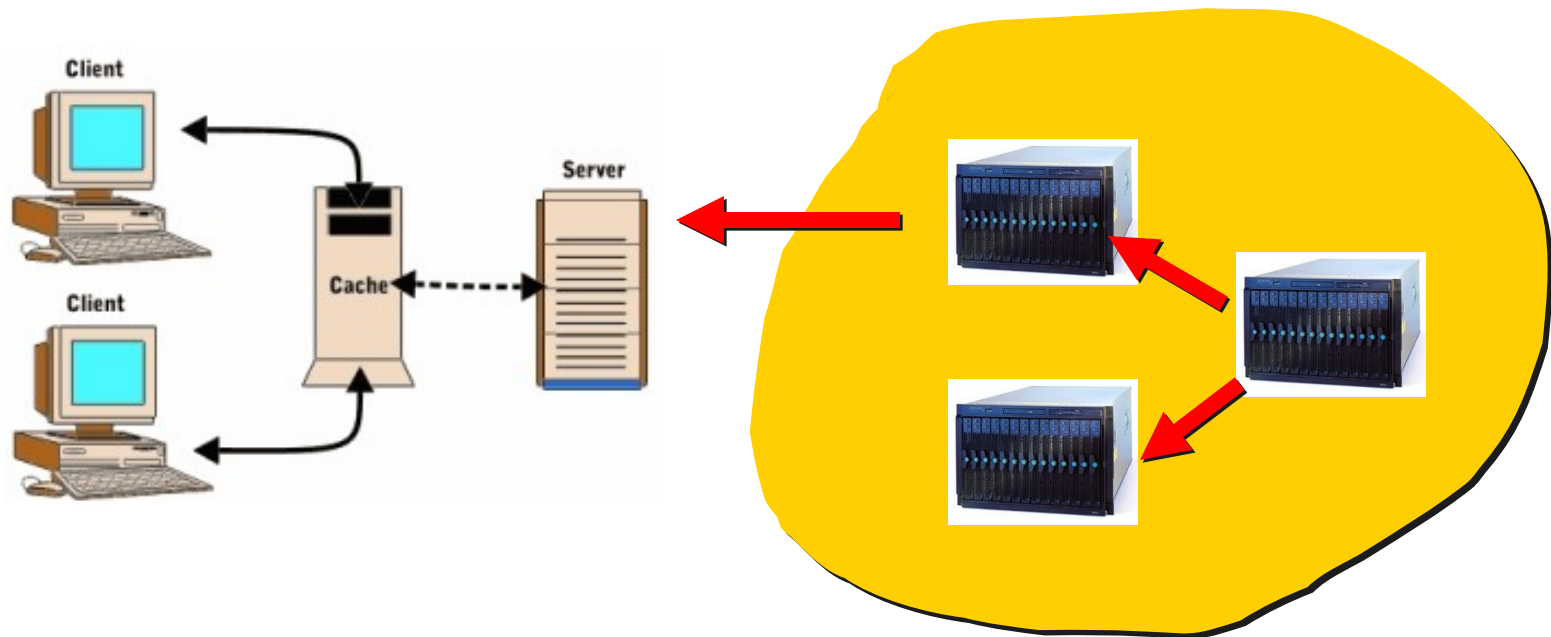
Internet evolution

- more bandwidth and switching capacity



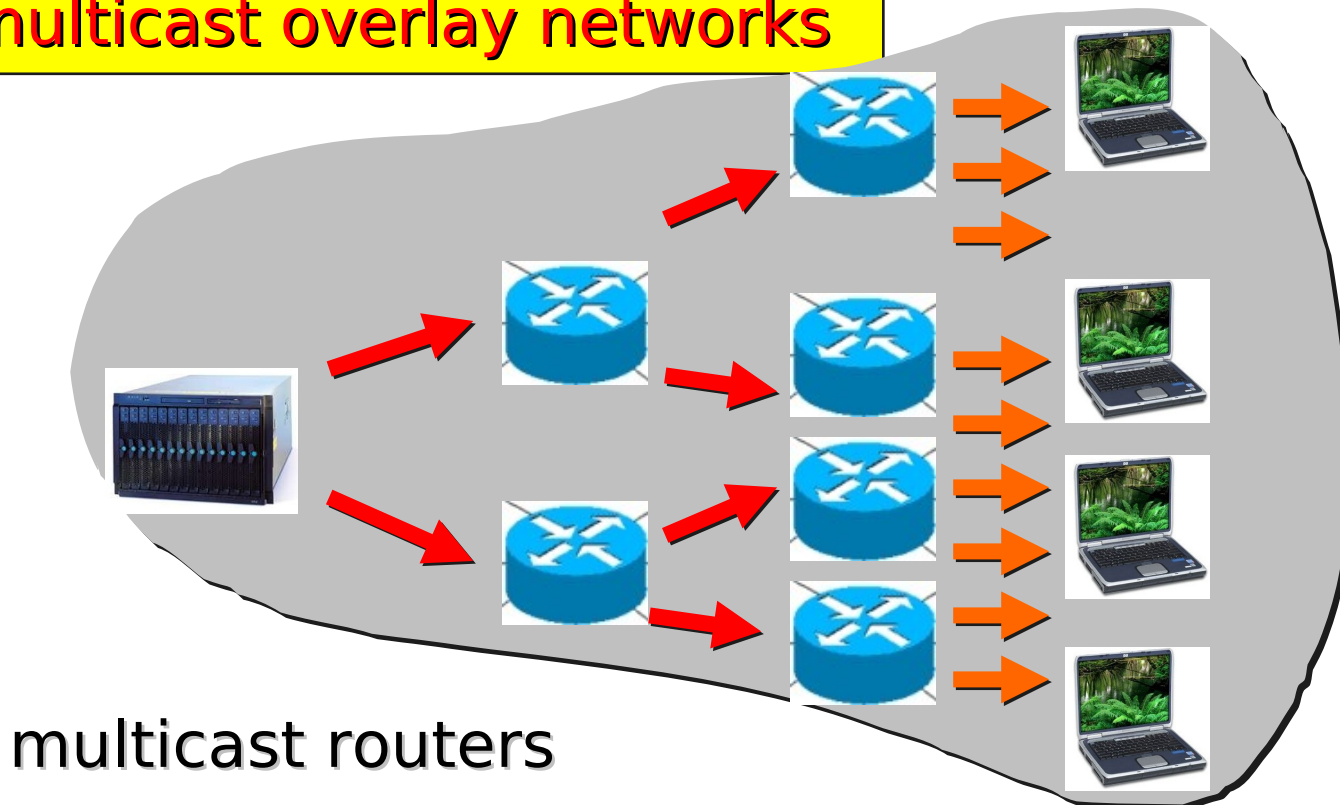
Internet evolution

- more bandwidth and switching capacity
- **content distribution by replication and caching**

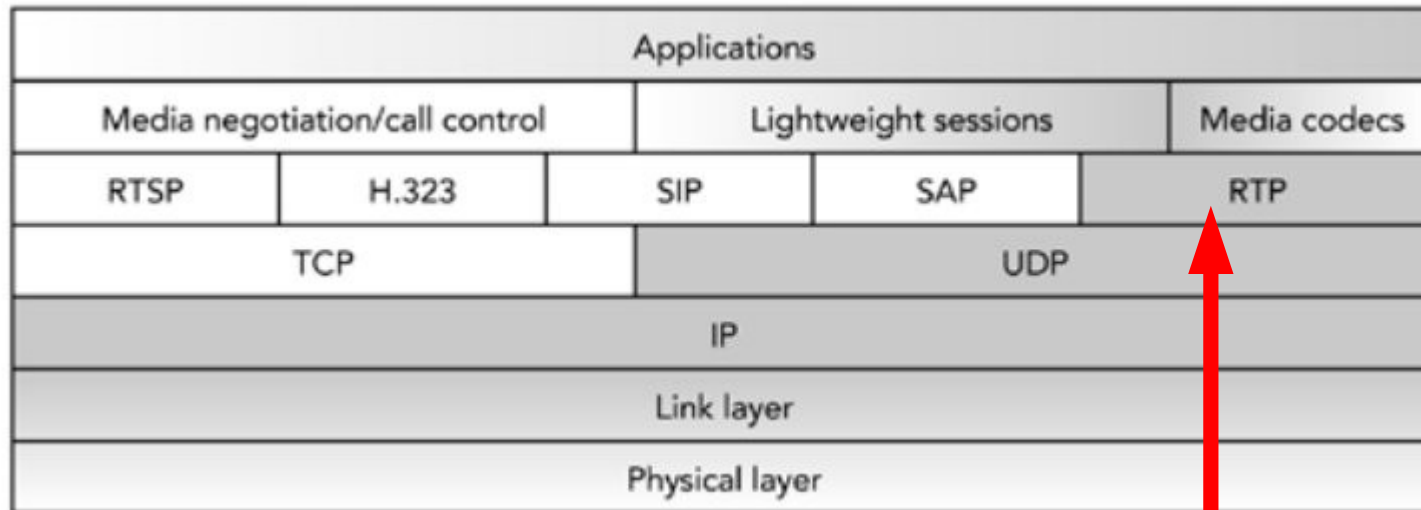


Internet evolution

- more bandwidth and switching capacity
- content distribution by replication and caching
- **multicast overlay networks**

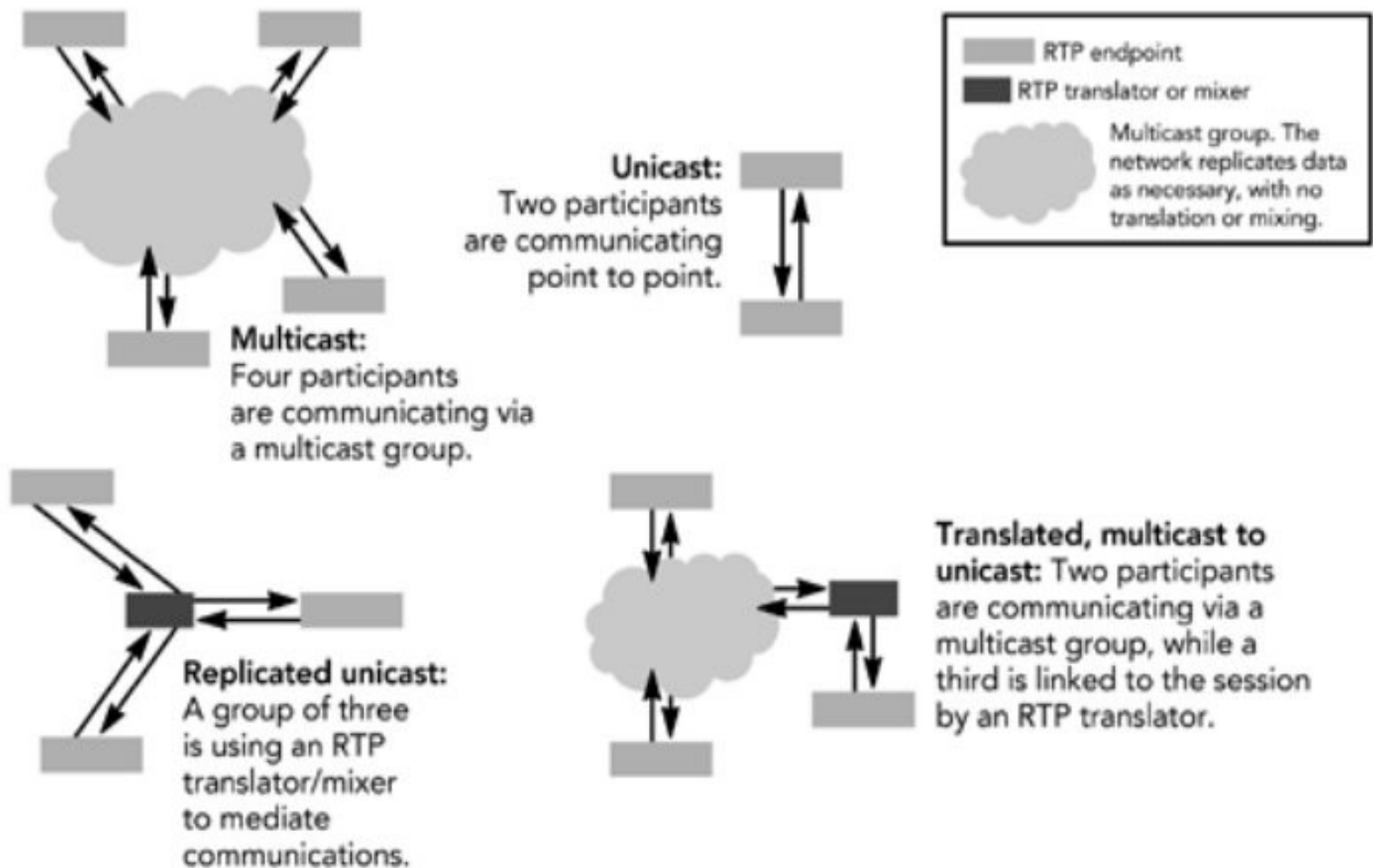


Multimedia protocol stack

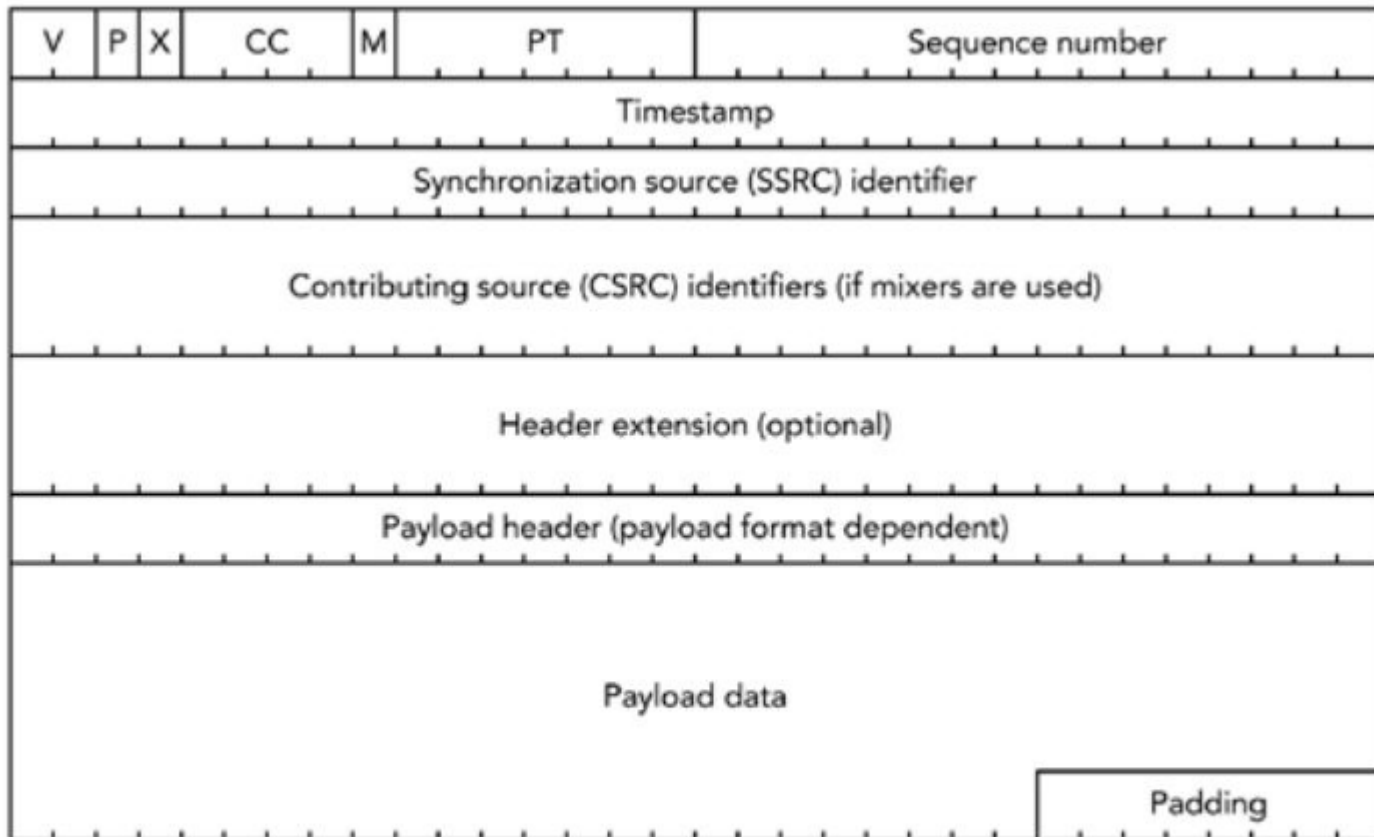


RTP and **RTCP**

RTP session types



RTP packet



V = version number
P = padding
X = extensions
CC = count of contributing sources
M = marker
PT = payload type

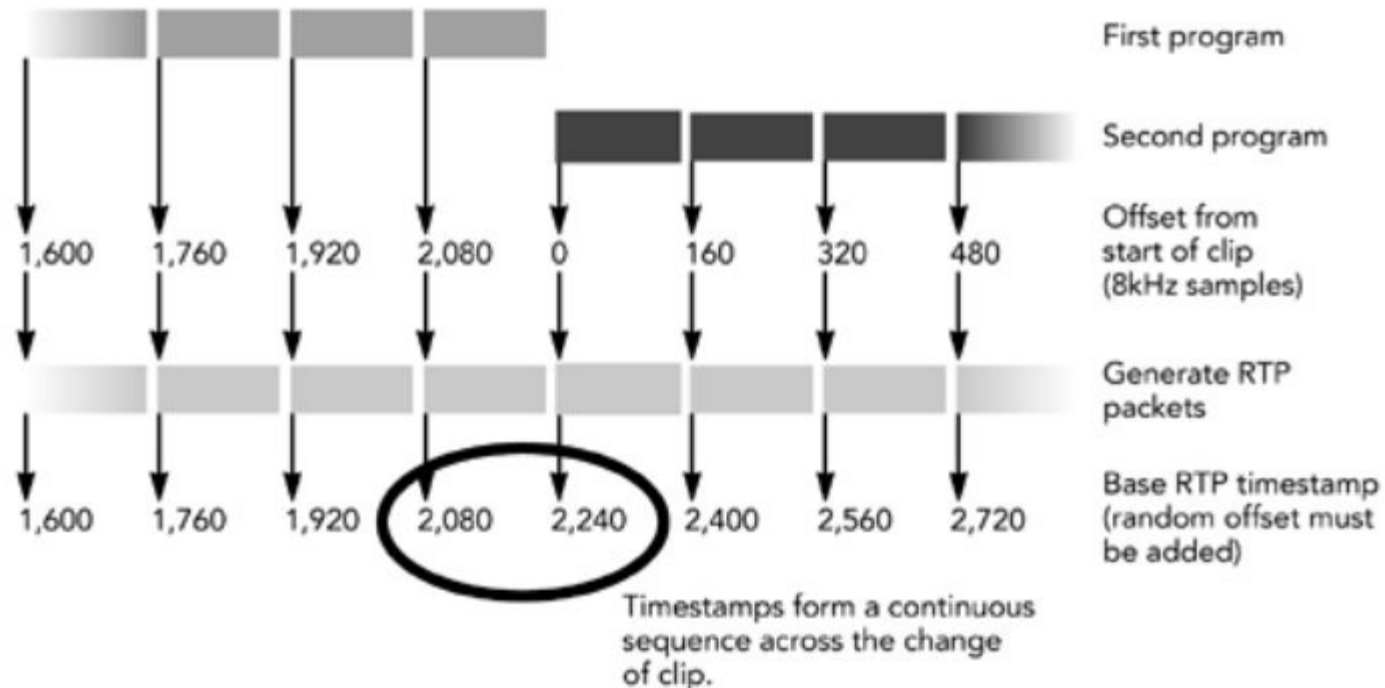
RTP packet : payload type

Payload Type Number	Payload Format	Specification	Description
0	AUDIO/PCMU	RFC 1890	ITU G.711 μ -law audio
3	AUDIO/GSM	RFC 1890	GSM full-rate audio
8	AUDIO/PCMA	RFC 1890	ITU G.711 A-law audio
12	AUDIO/QCELP	RFC 2658	PureVoice QCELP audio
14	AUDIO/MPA	RFC 2250	MPEG audio (e.g., MP3)
26	VIDEO/JPEG	RFC 2435	Motion JPEG video
31	VIDEO/H261	RFC 2032	ITU H.261 video
32	VIDEO/MPV	RFC 2250	MPEG I/II video

96 to 127 - dynamic (includes H264)

RTP packet : timestamp

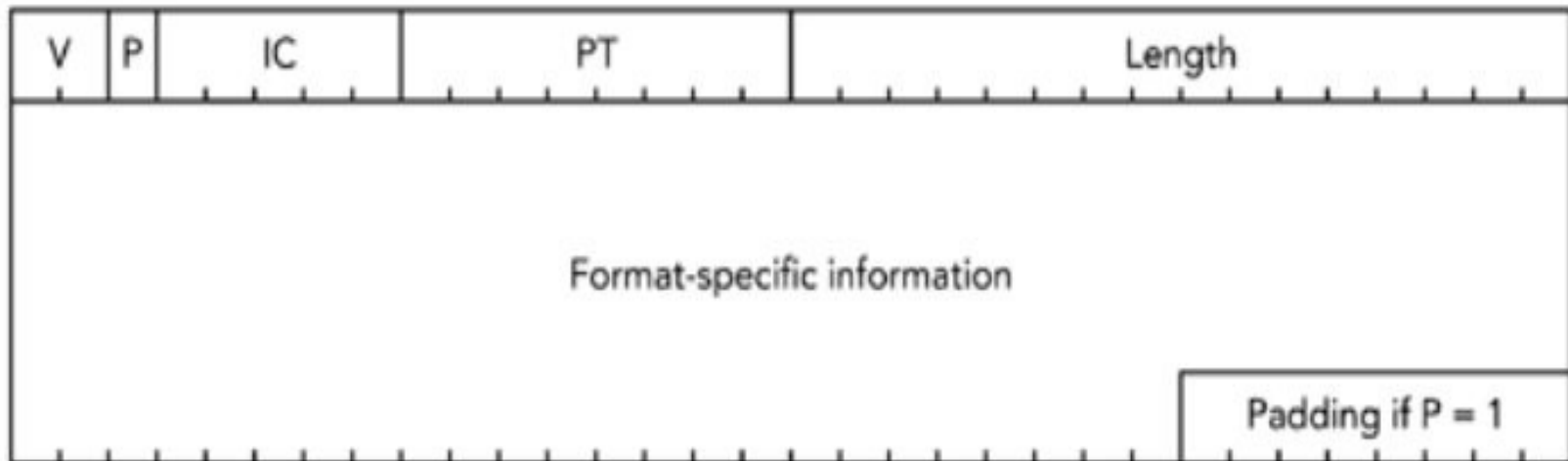
audio



$20 \text{ ms} * 8000 \text{ 1/s} \Rightarrow 160 \text{ (timestamp distance)}$

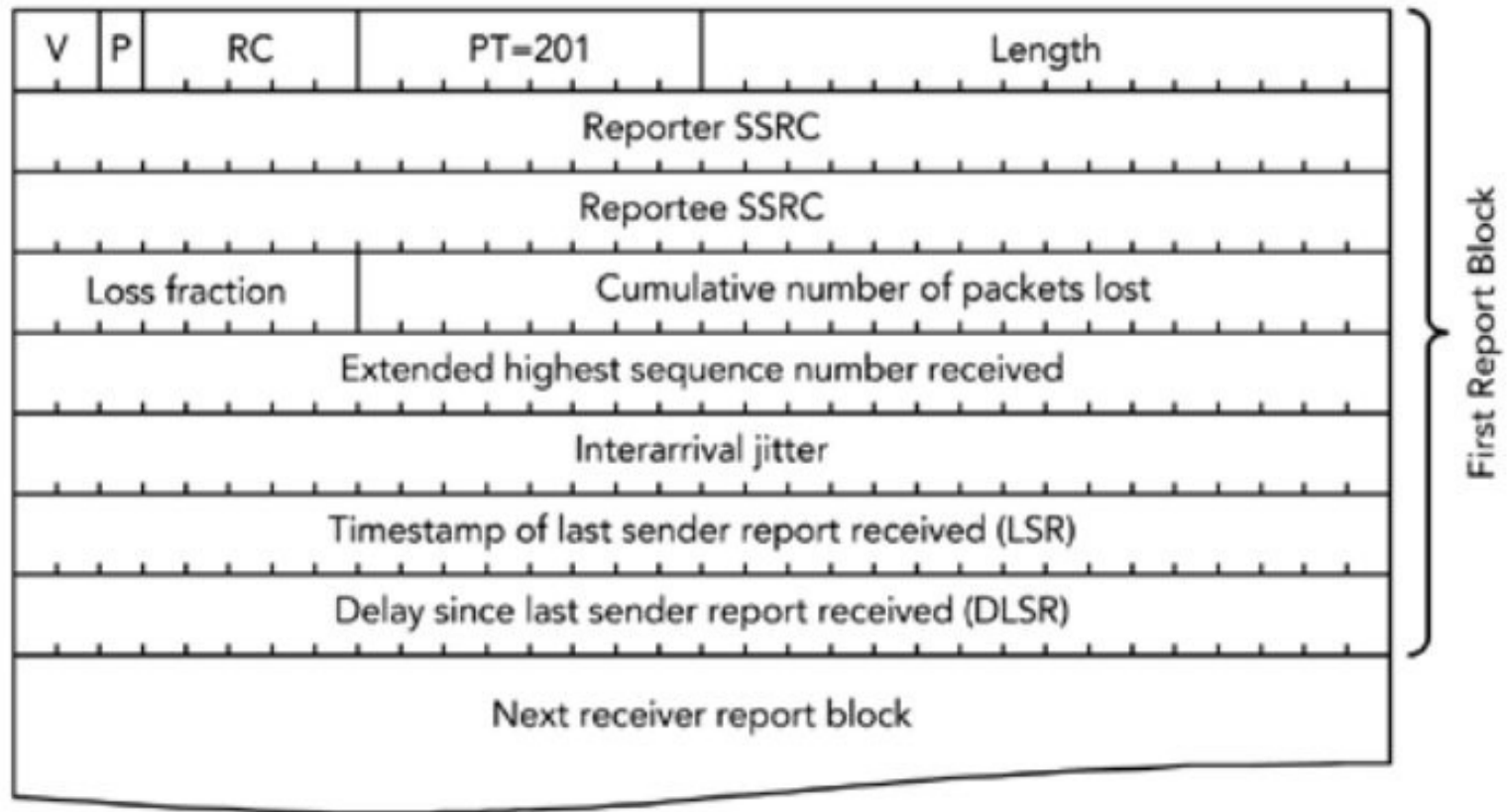
reference - media clock
audio (8kHz), video (96KHz)

RTCP packet



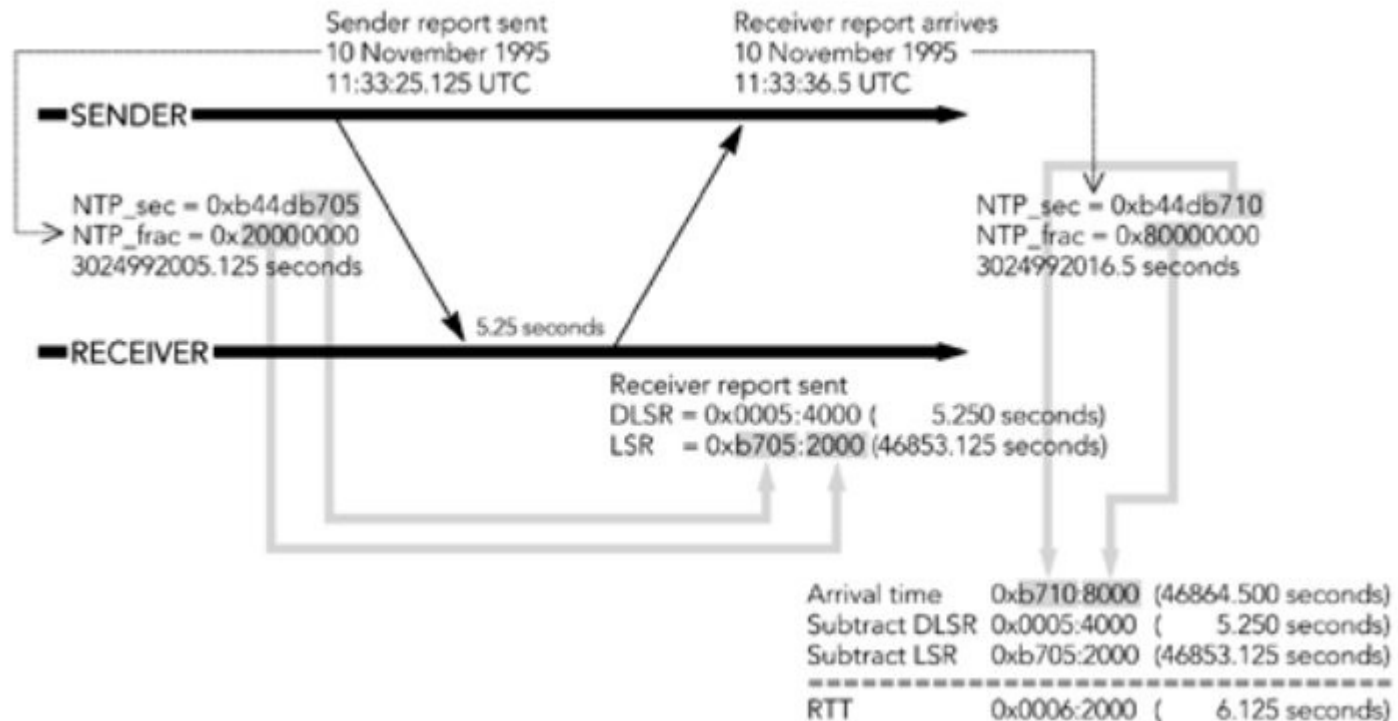
V = version number
P = padding
IC = item count
PT = packet type

RTCP packet: receiver report



V = version number
P = padding
RC = number of receiver report blocks
PT = packet type

RTT time computation



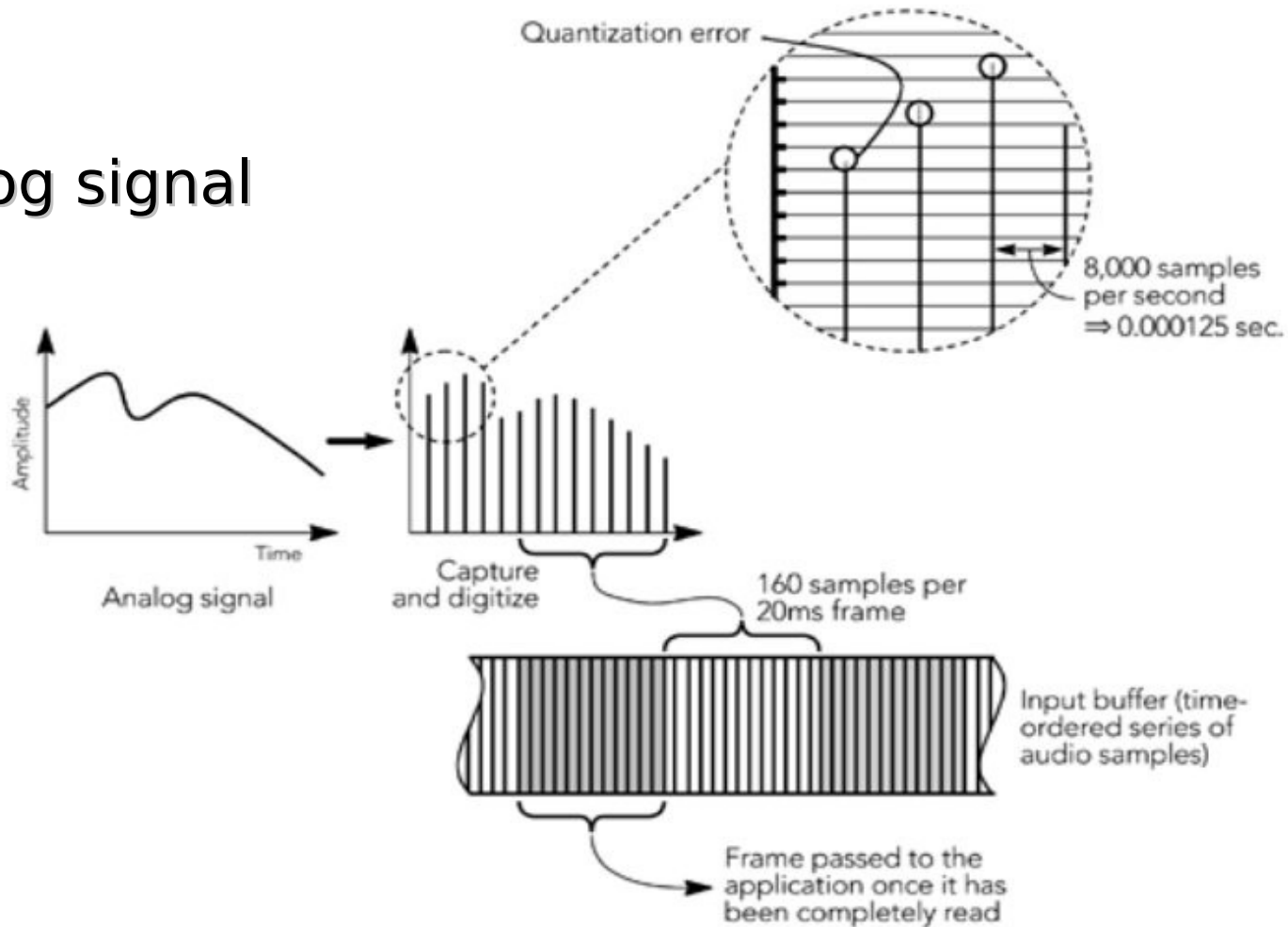
NTP – Network Time Protocol – data on 64 bits

0xb44db**705** - seconds

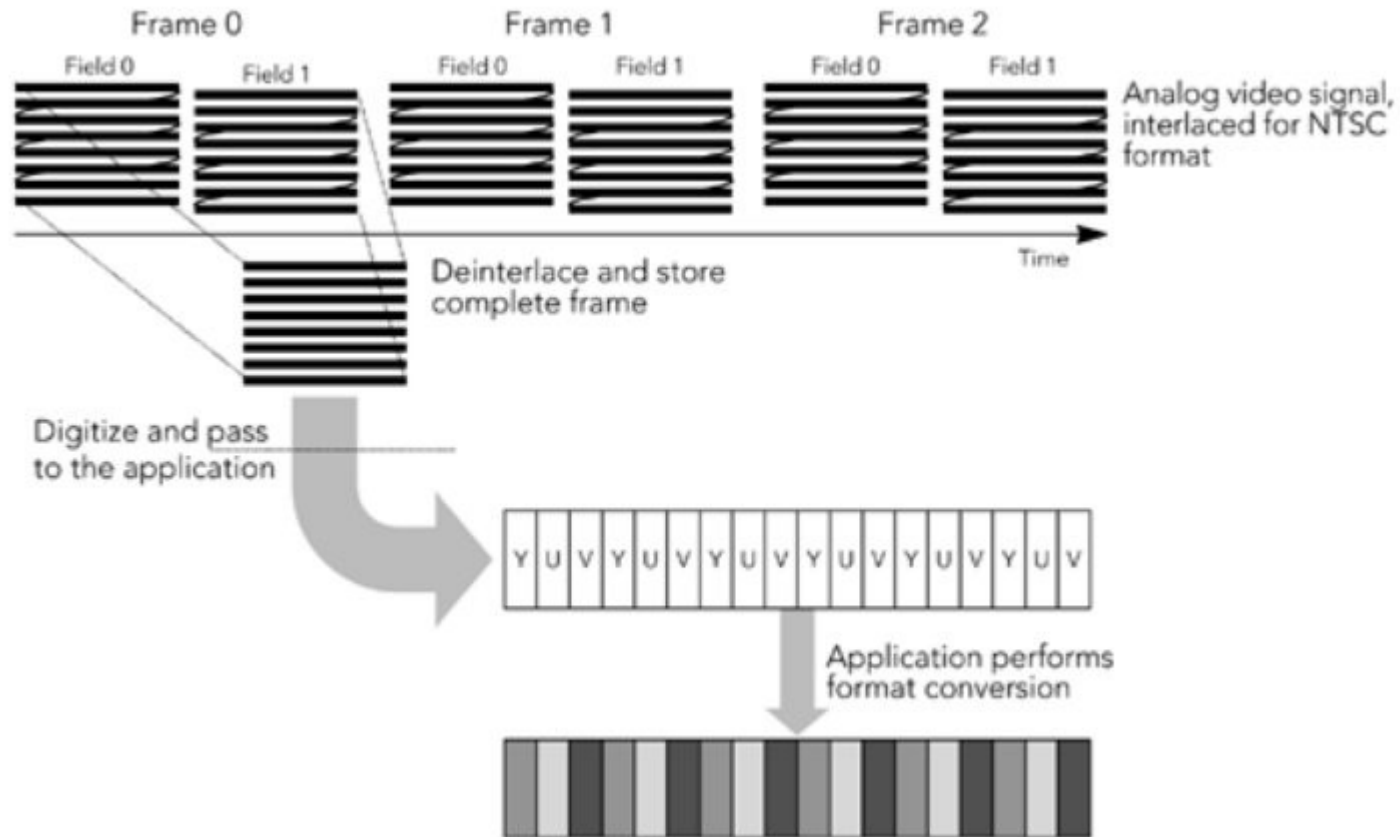
0x**2000**0000 - fraction of second

Audio capture

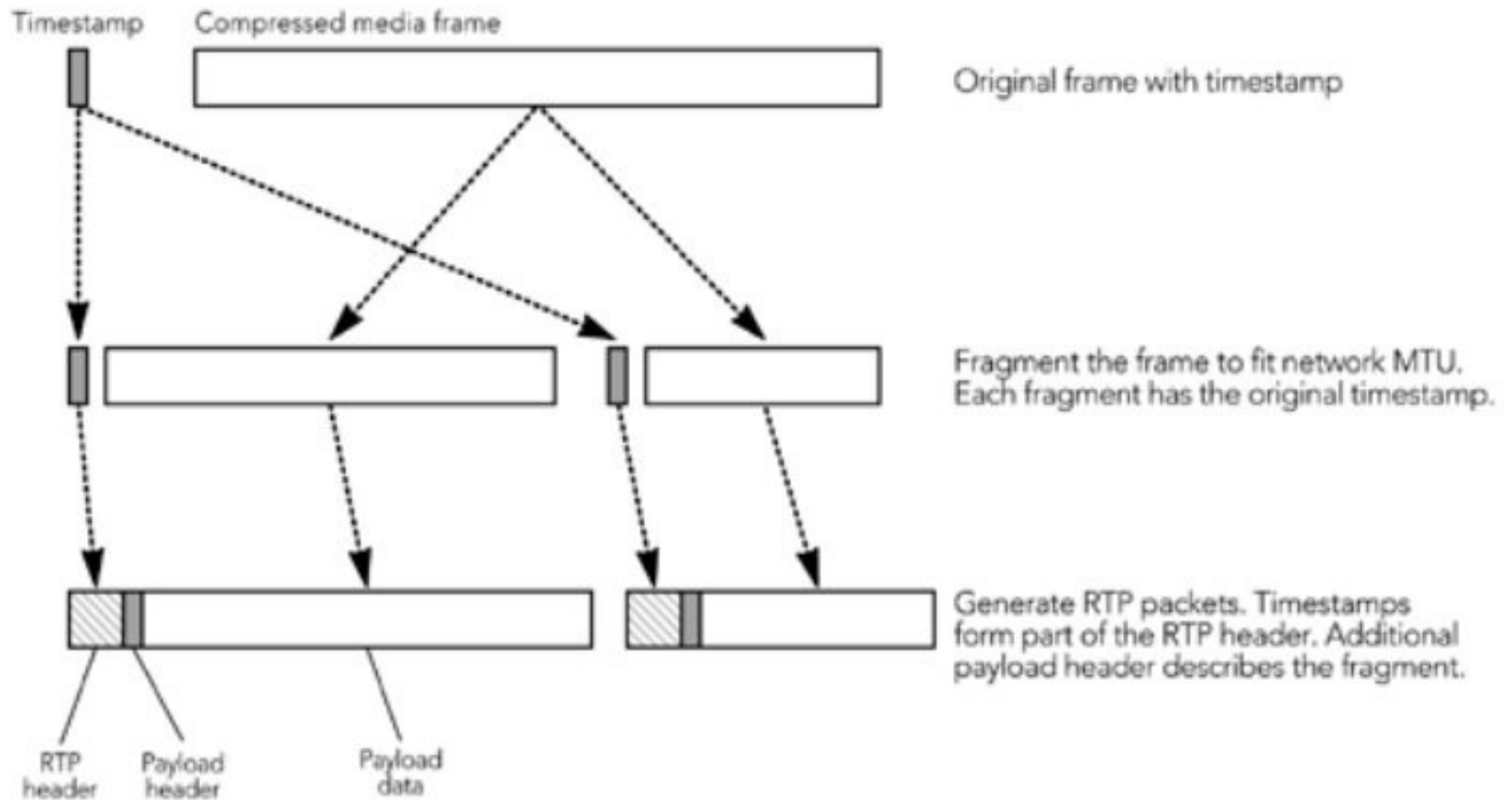
analog signal



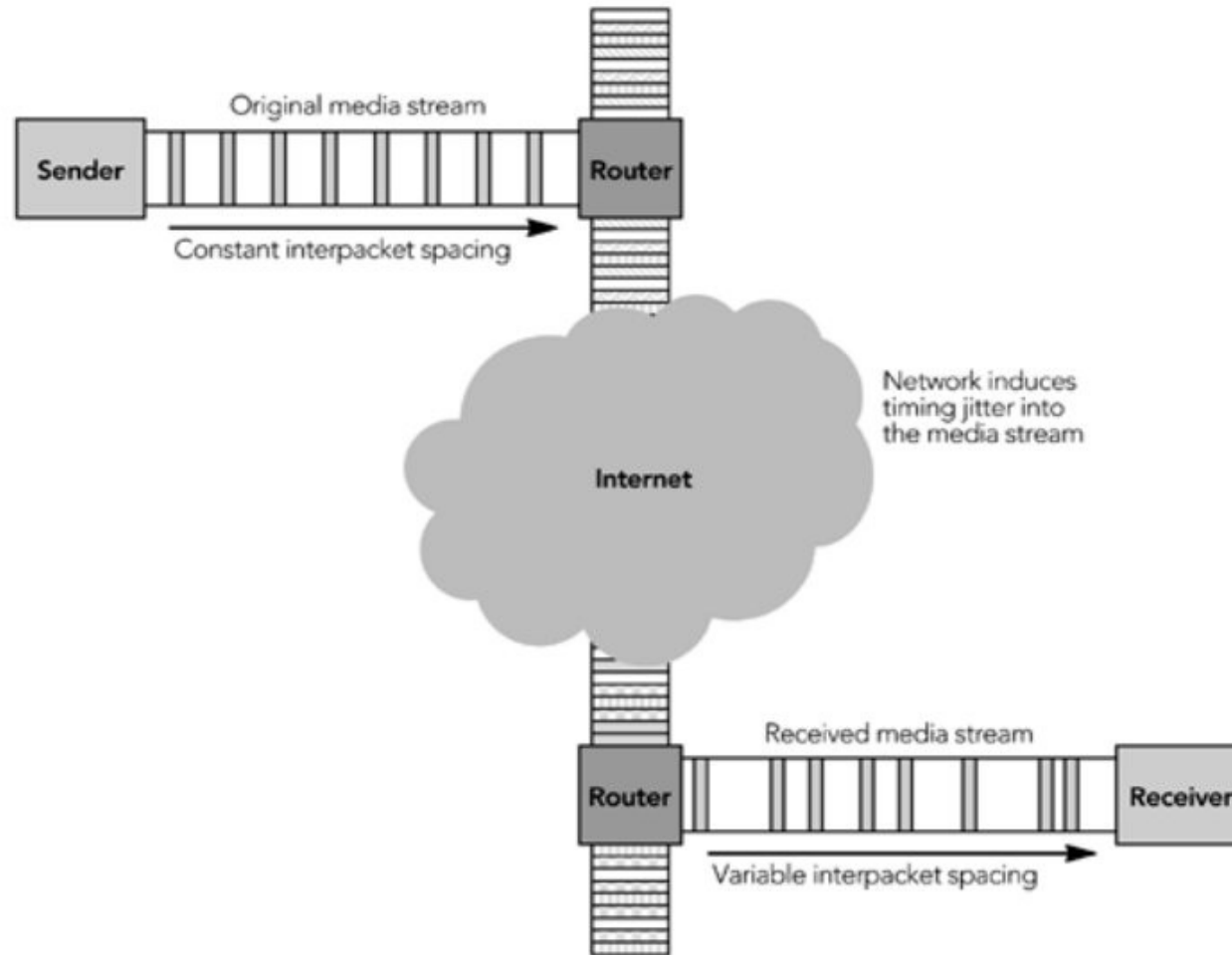
Video capture



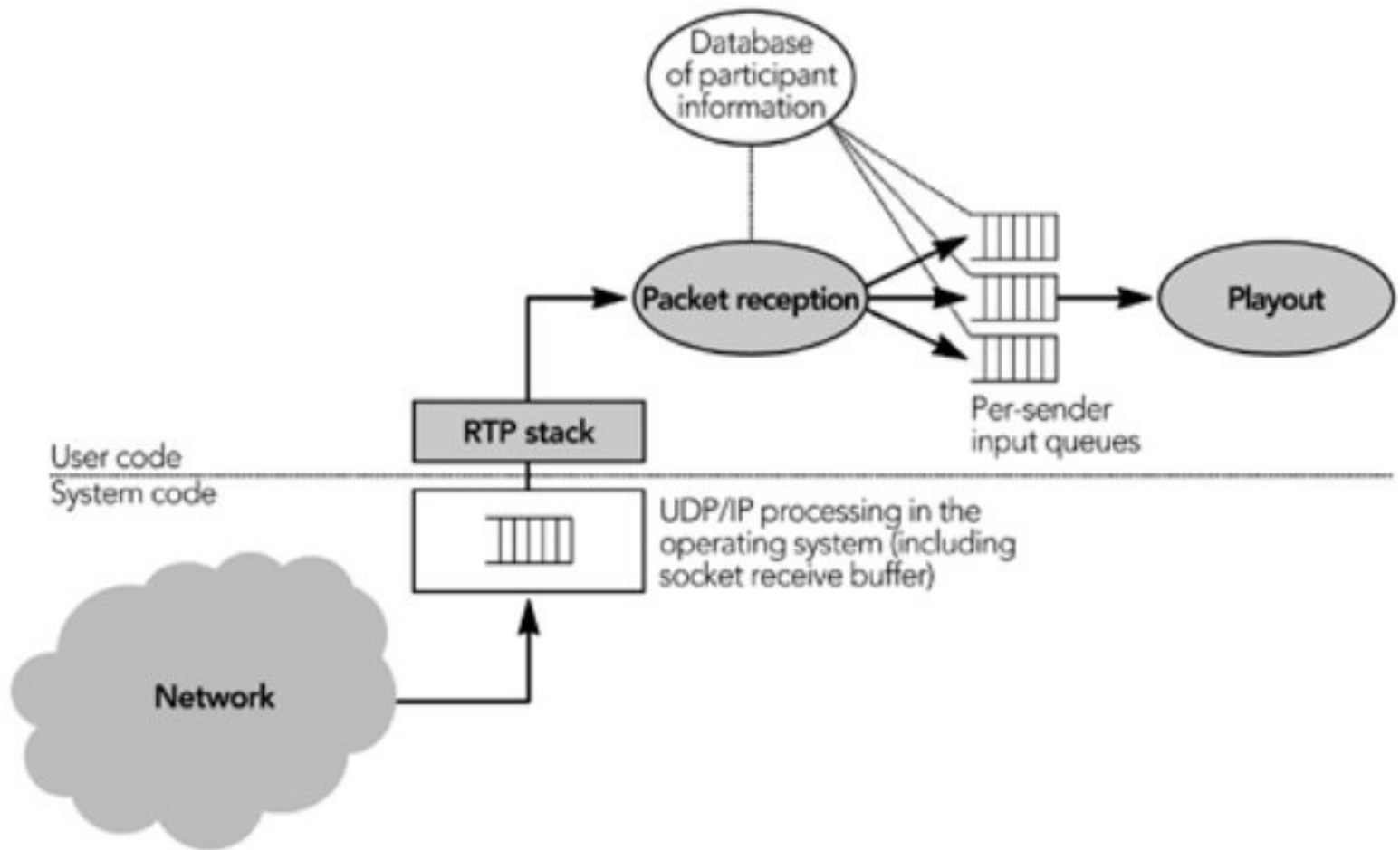
Media frames & packets



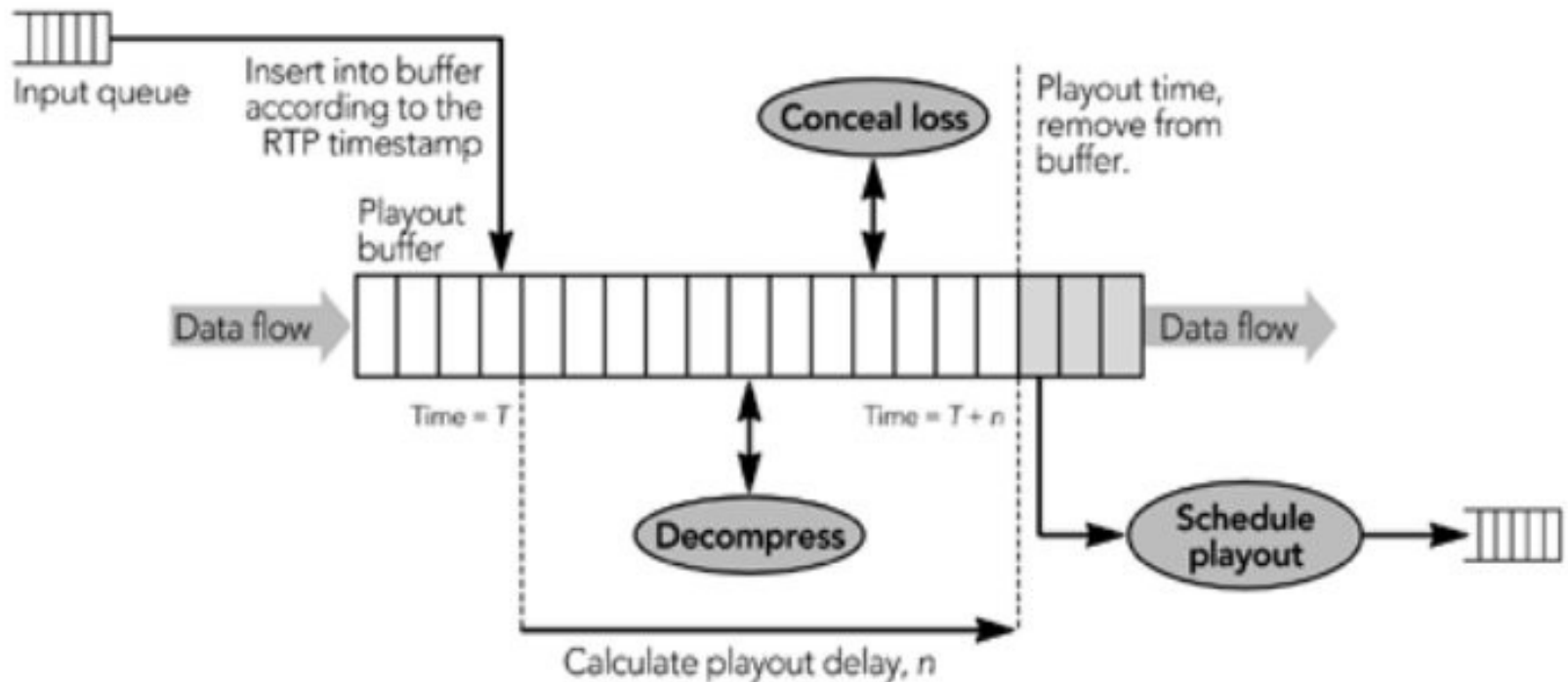
Packet timing - disruption



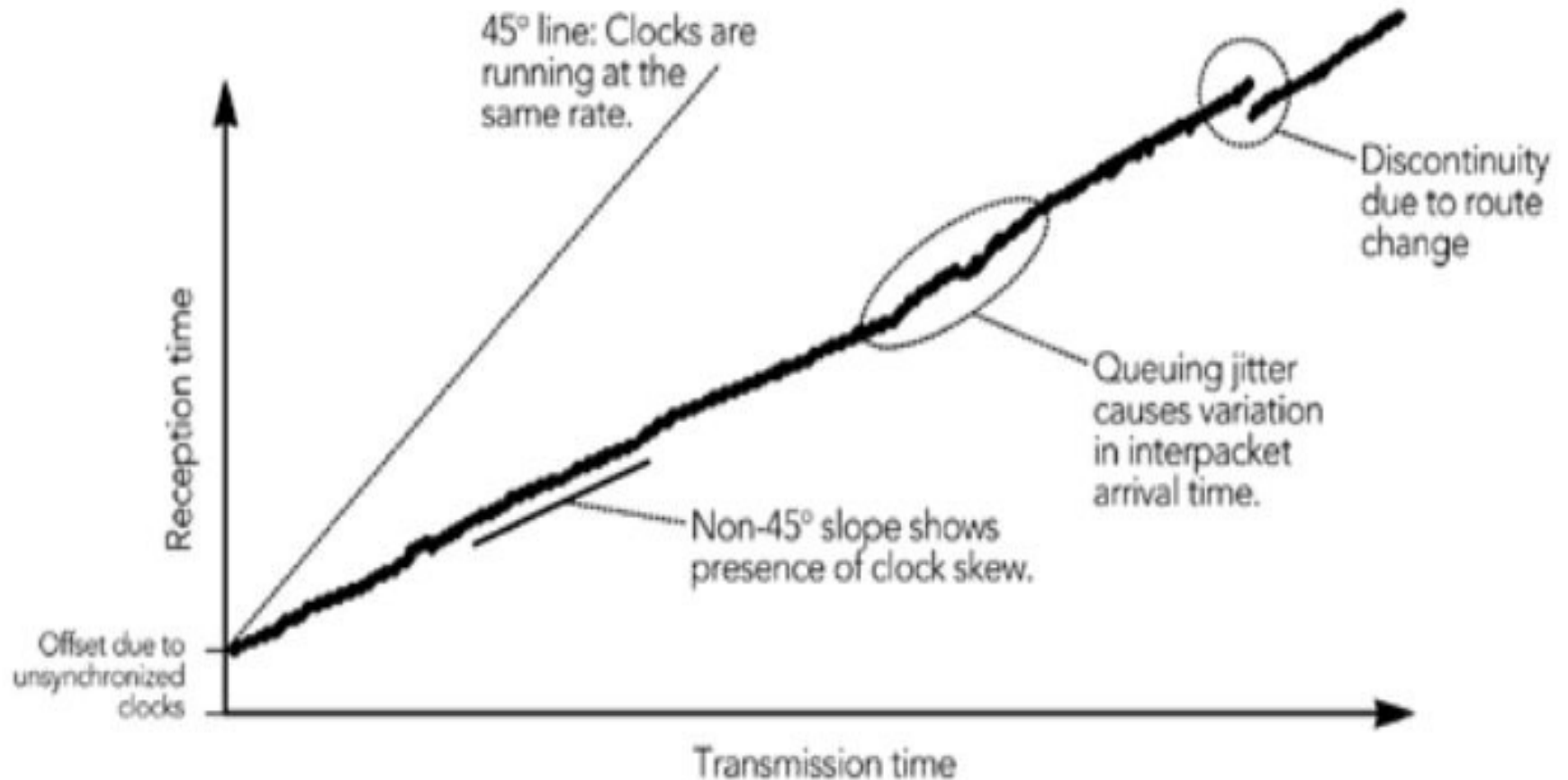
Packet reception & play-out



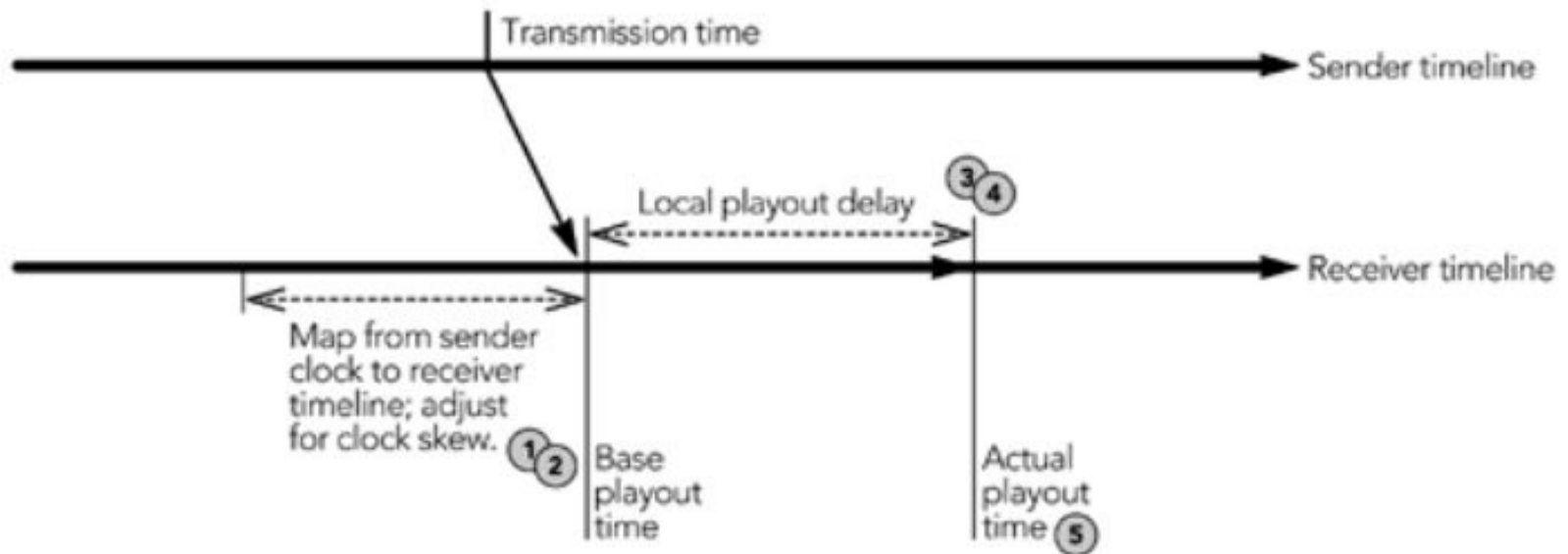
Play-out buffer



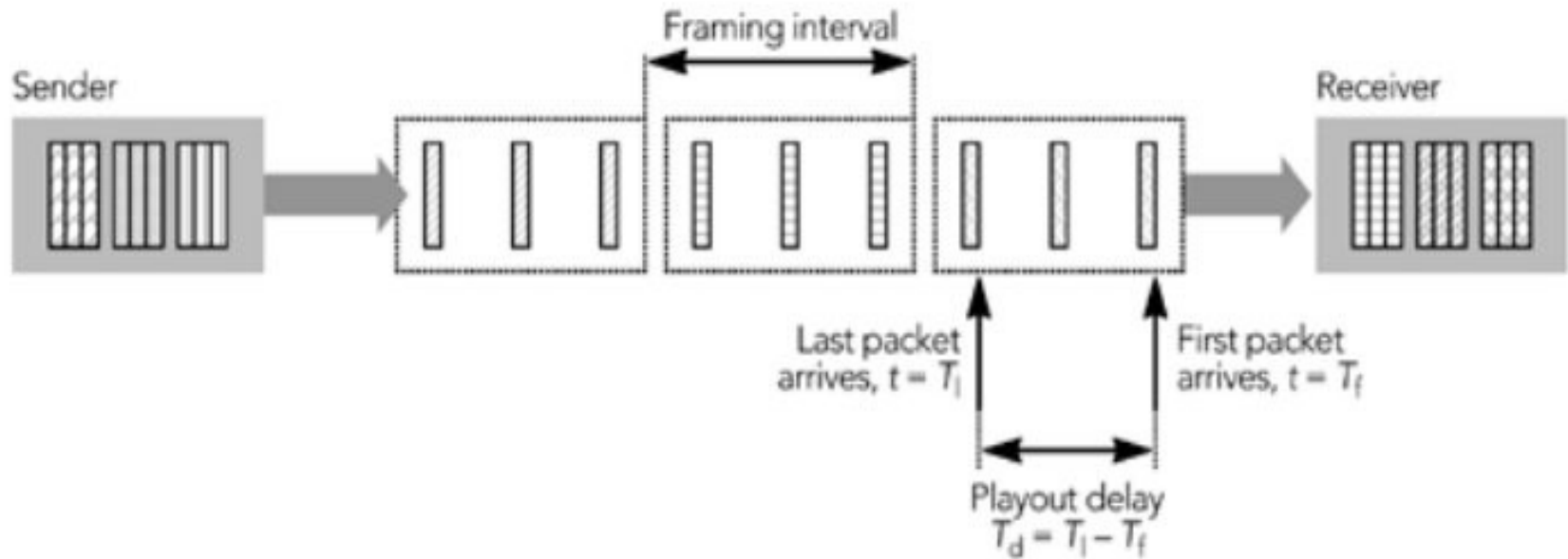
Play-out clock skew



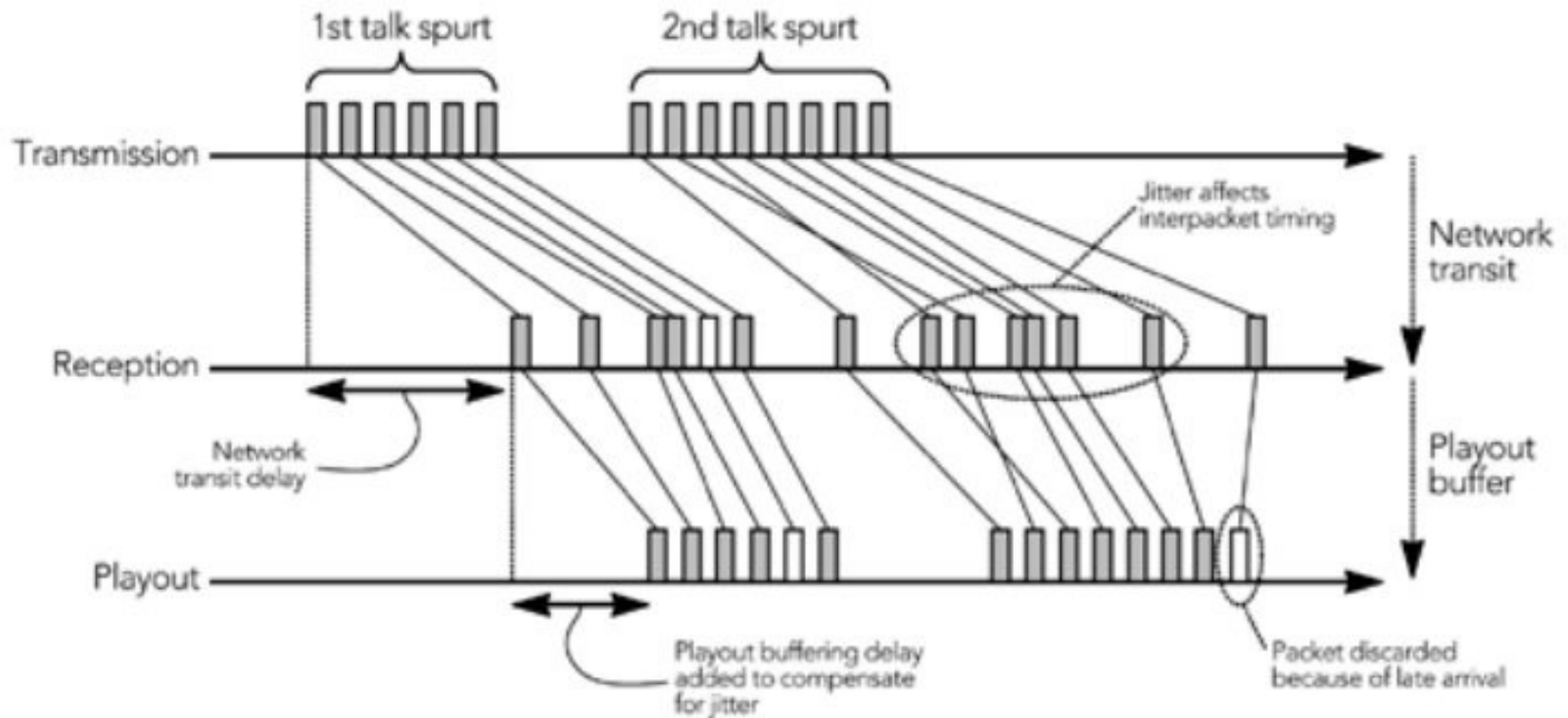
Play-out time calculation



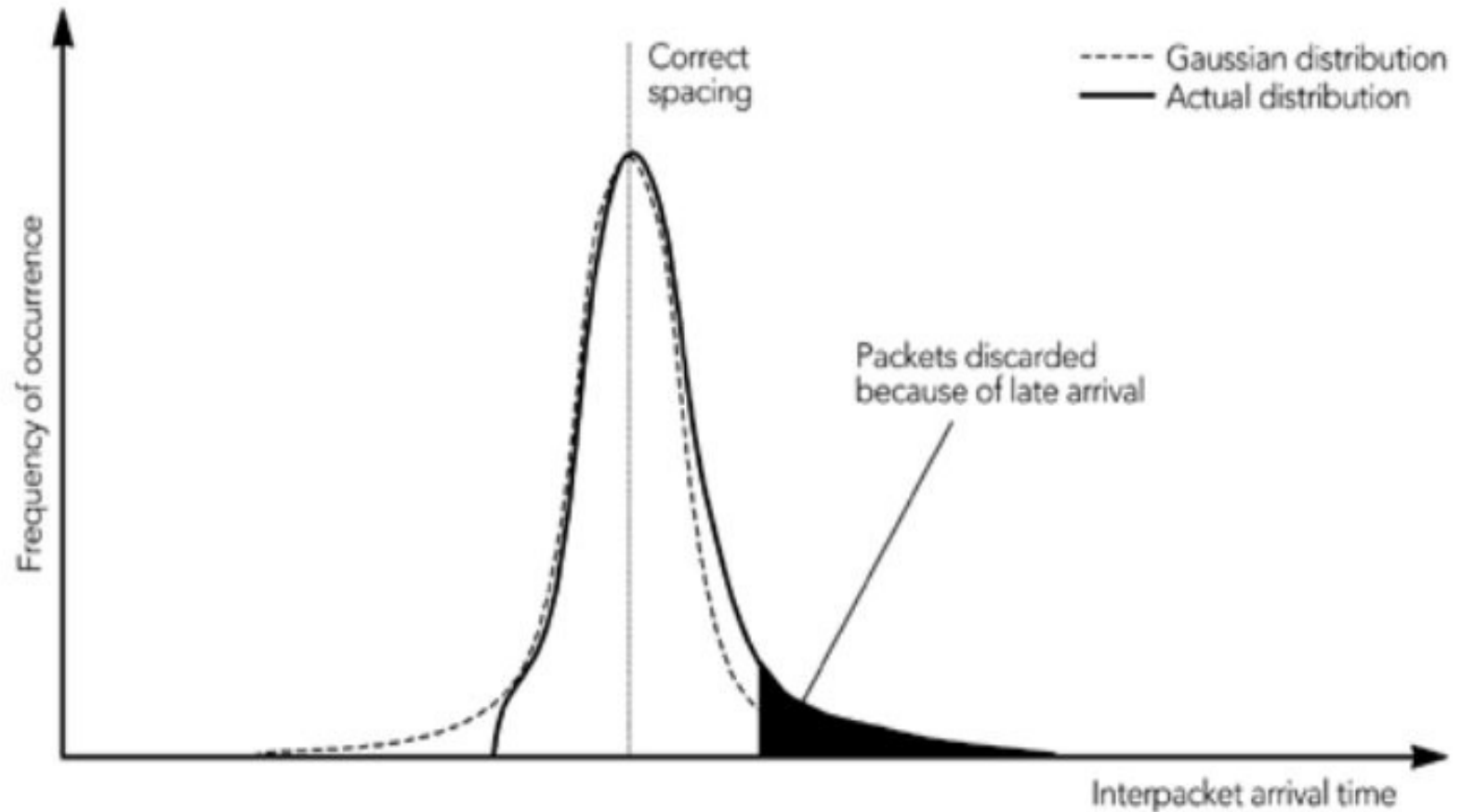
Buffering delay



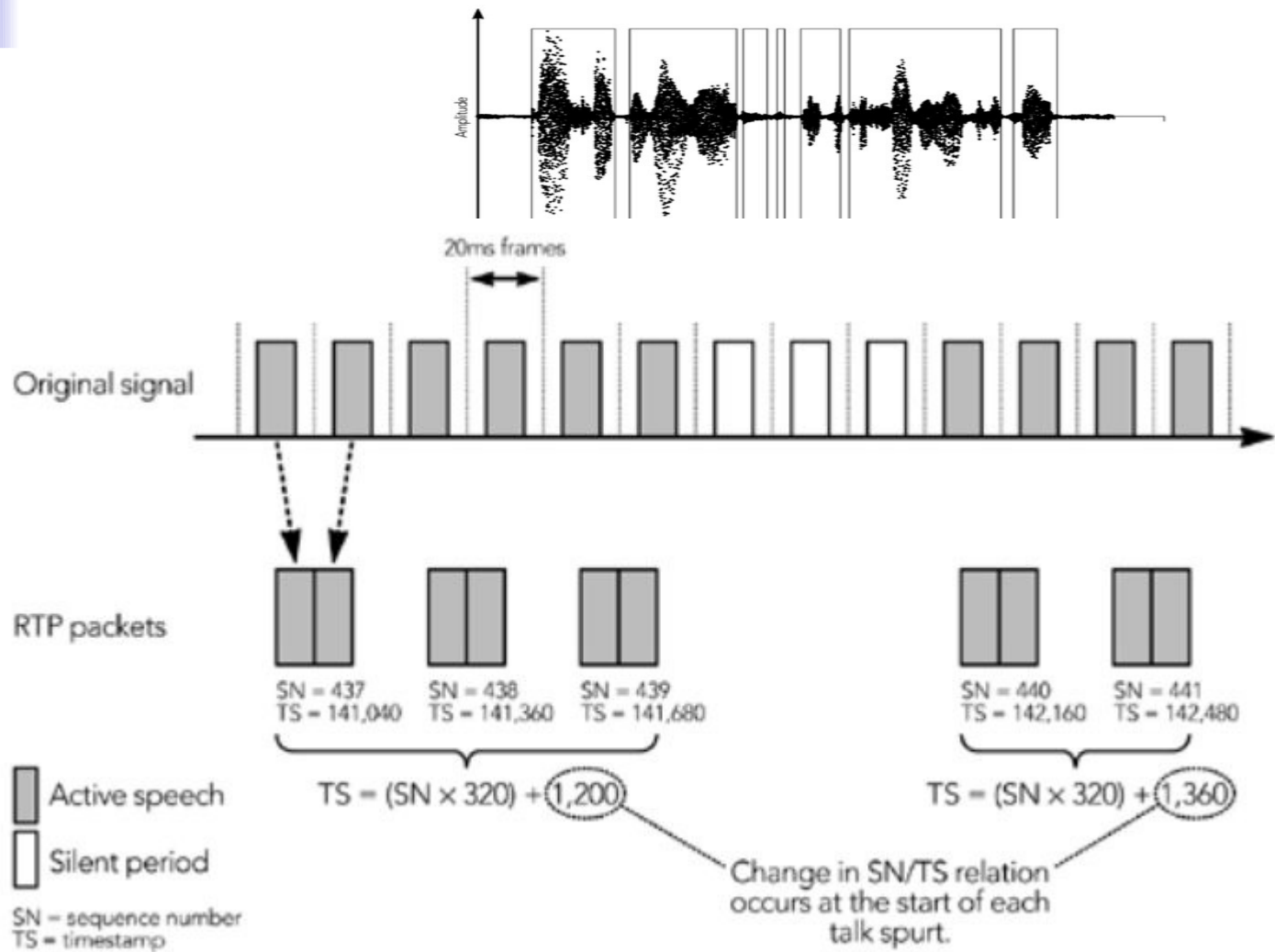
Buffering – network jitter



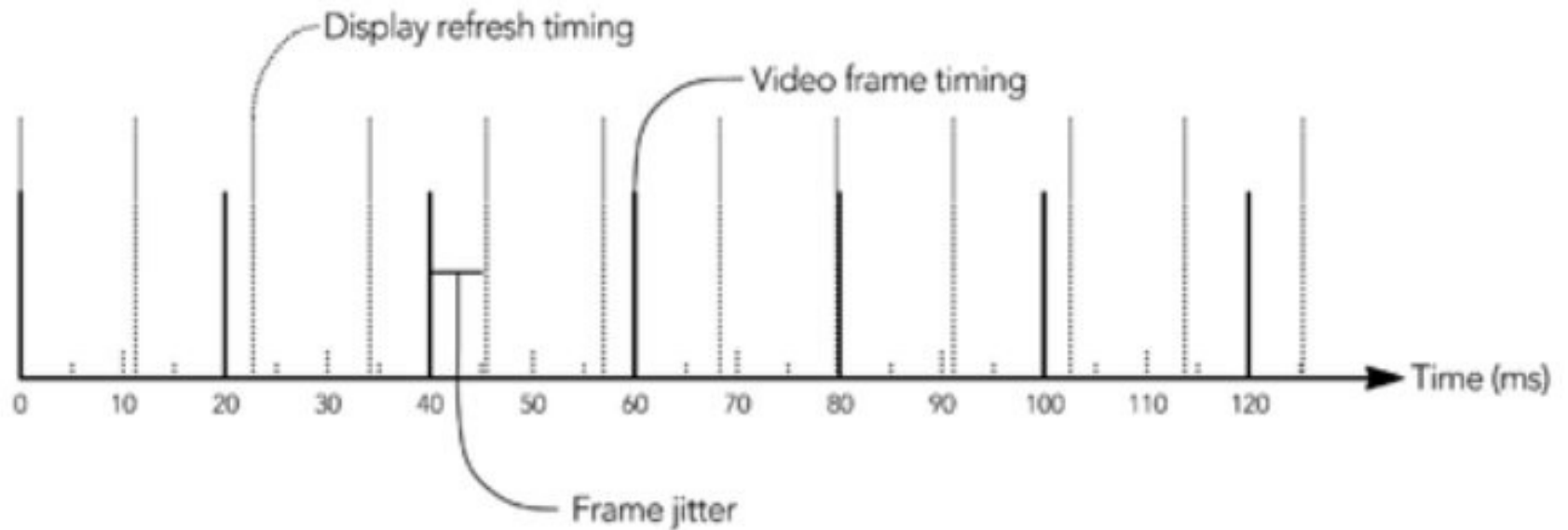
Distribution of network jitter



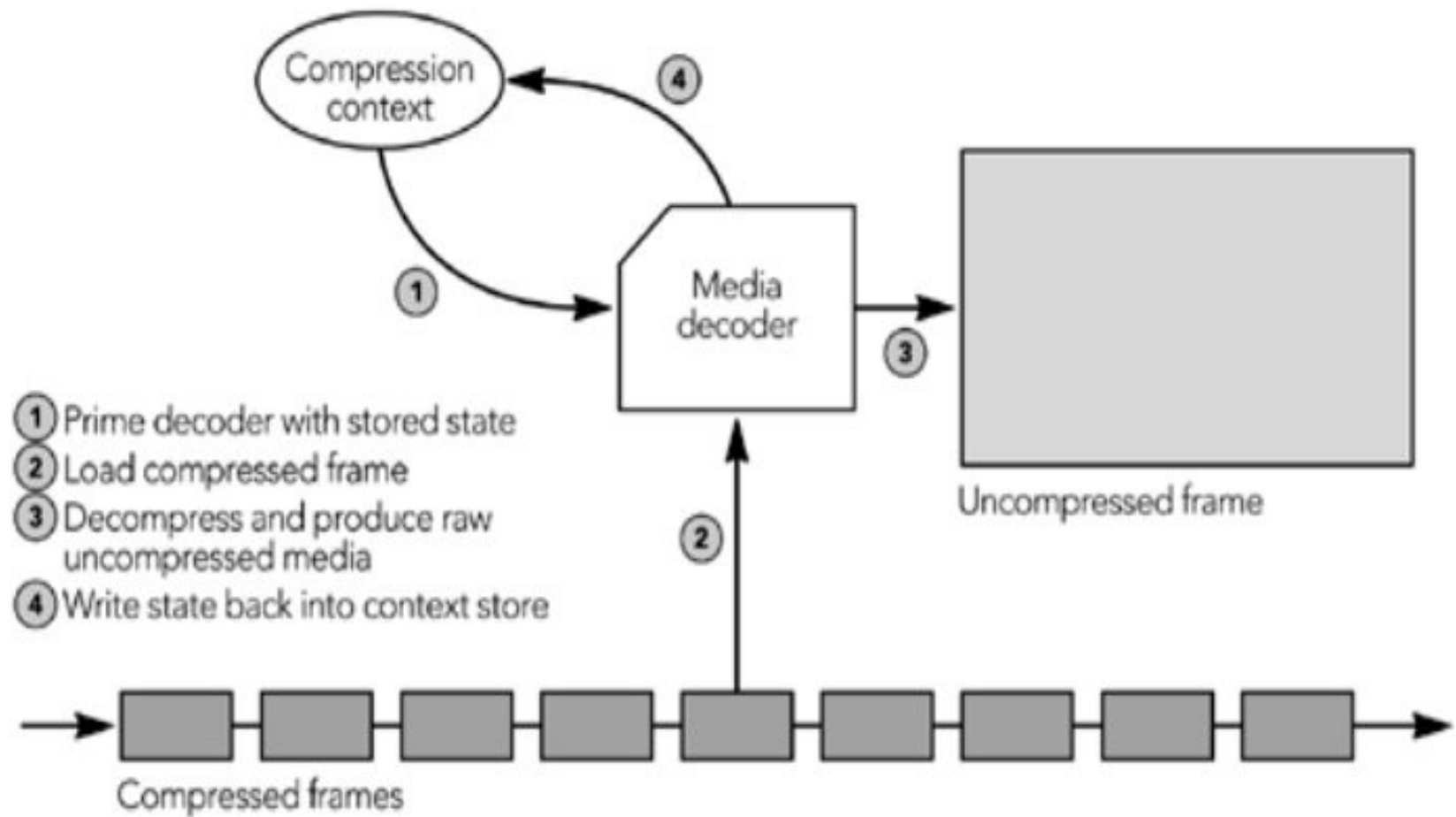
Talk spurts (SN & TS relation)



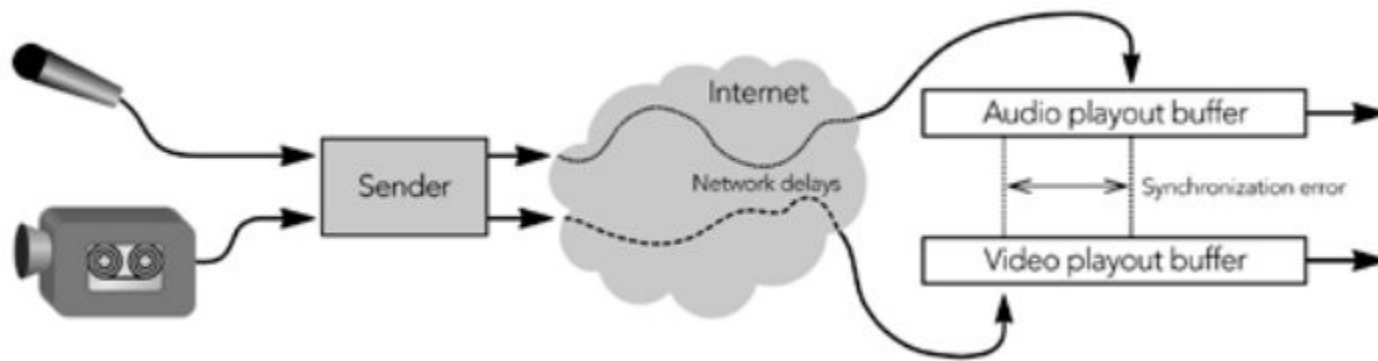
Media frames & Players



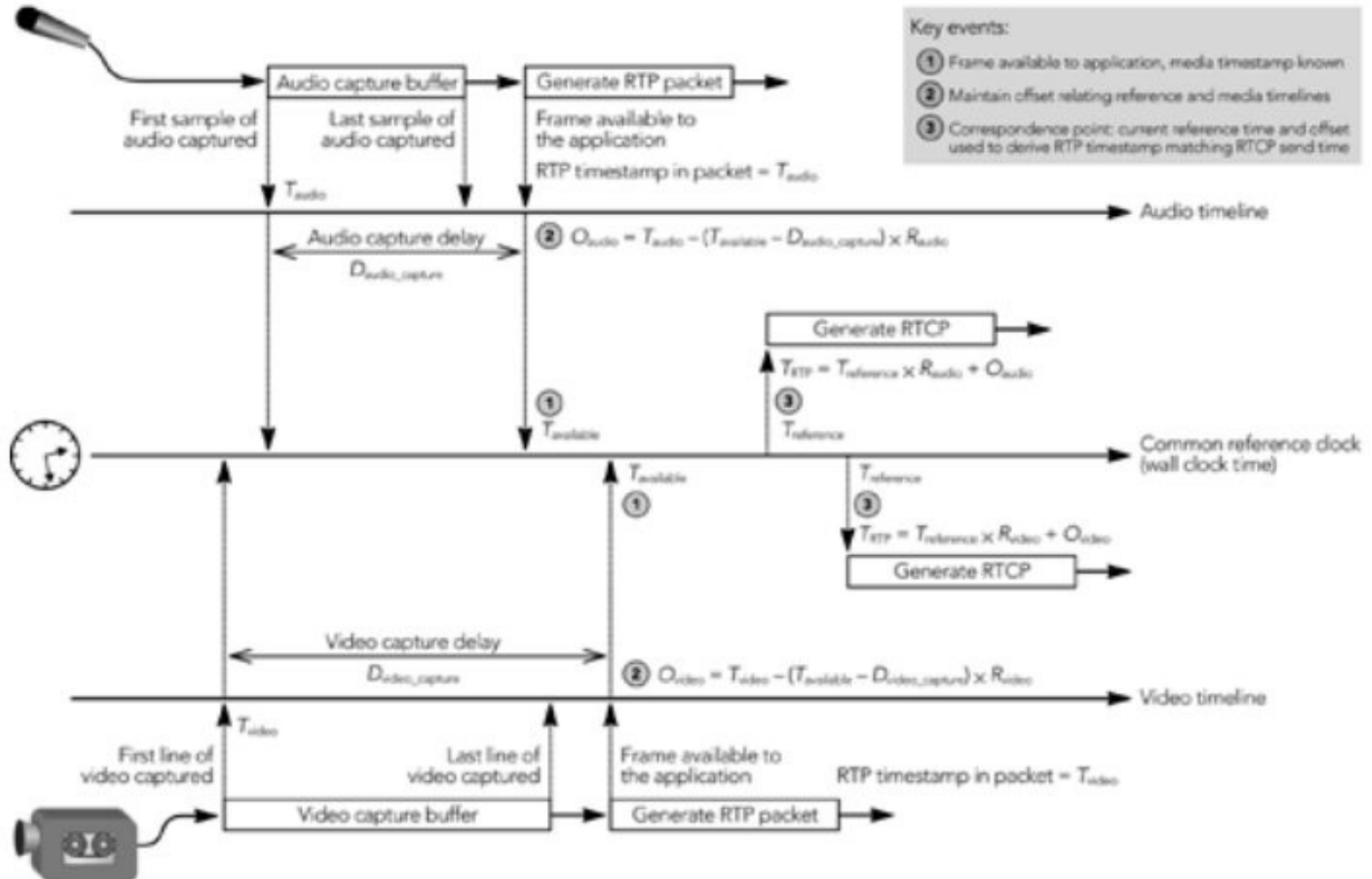
Operation of media decoder



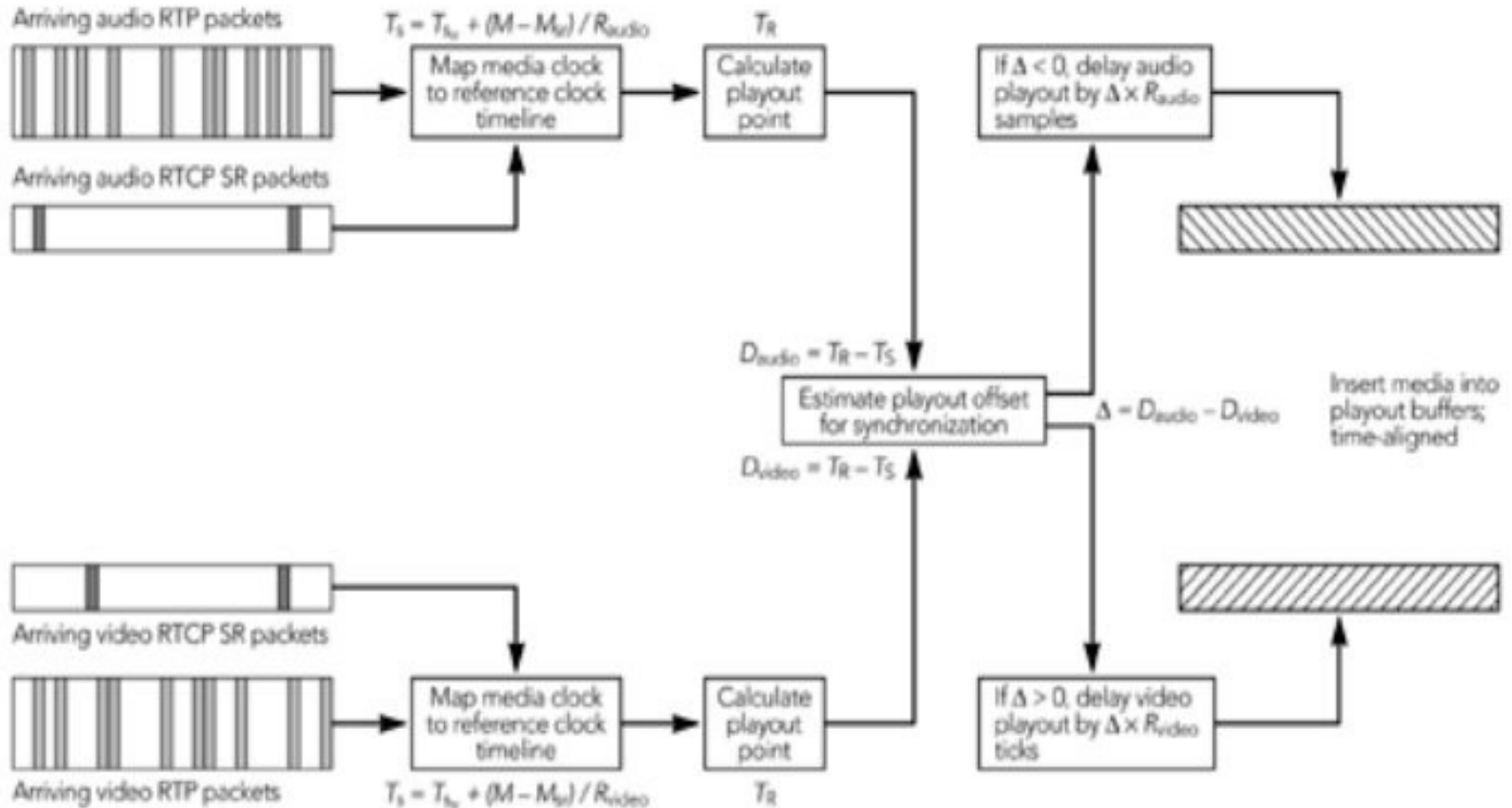
Media multiplexing



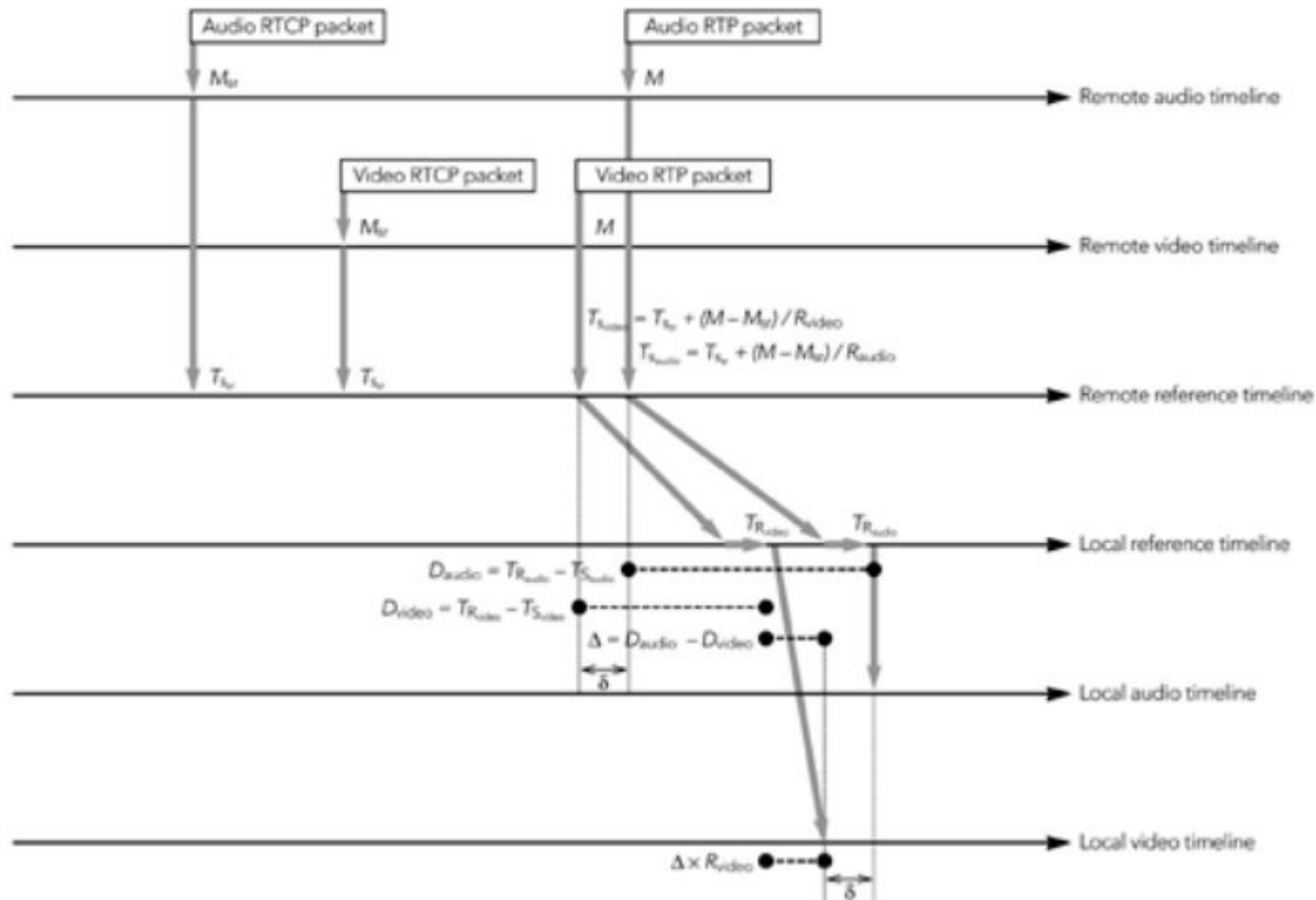
Multiplexing time-line



Receiver lip synchronization



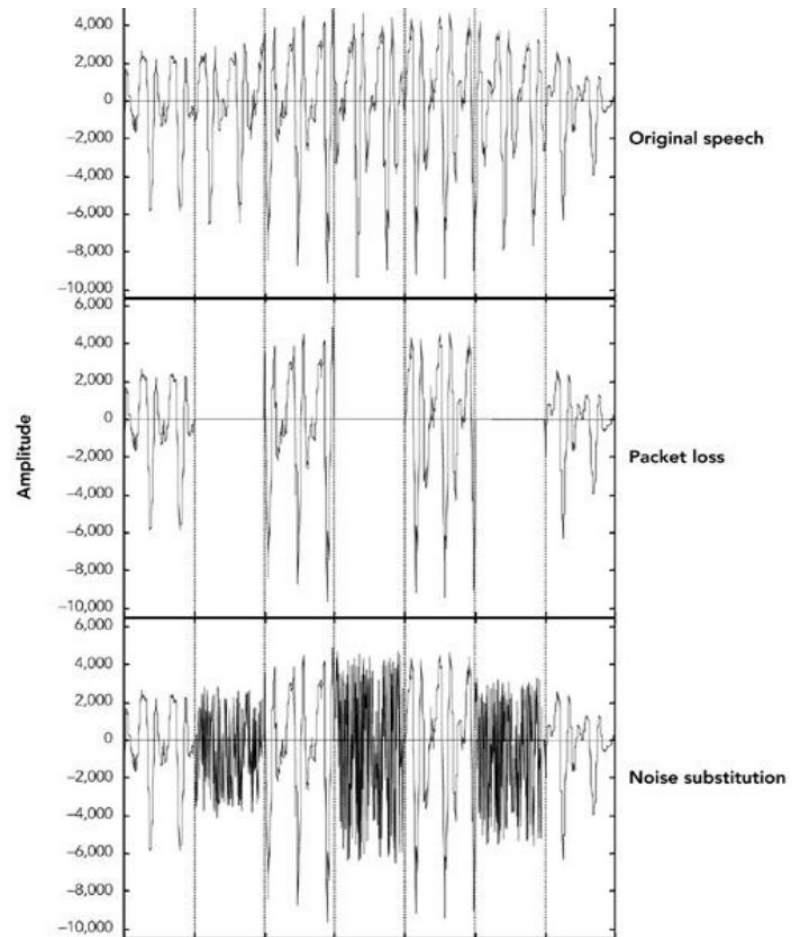
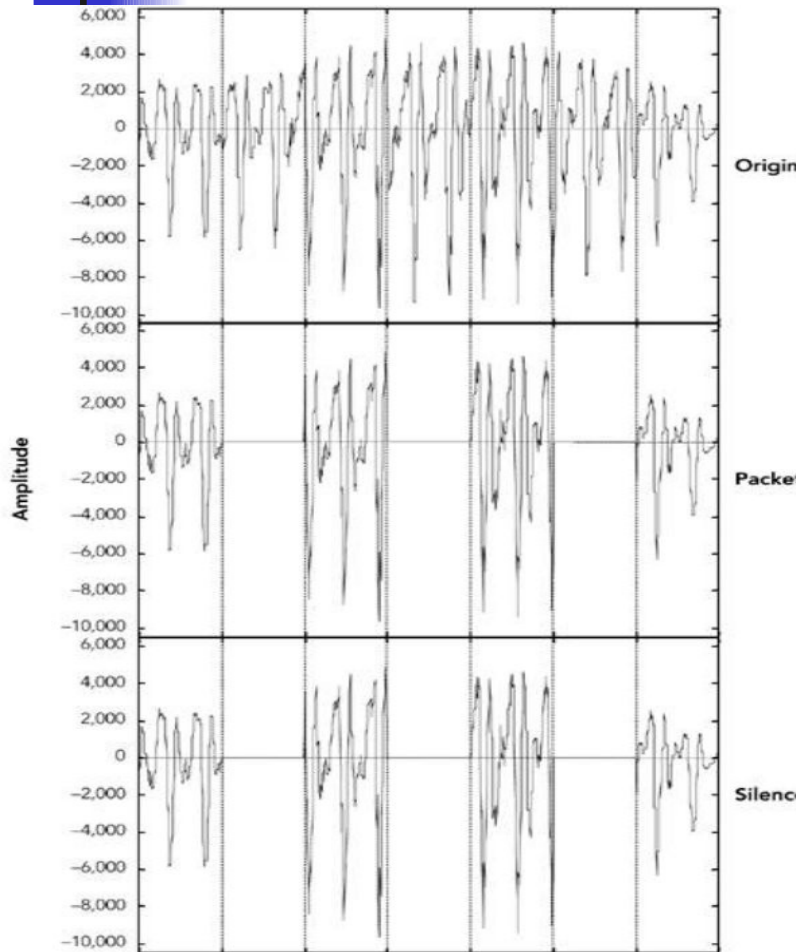
Receiver time lines



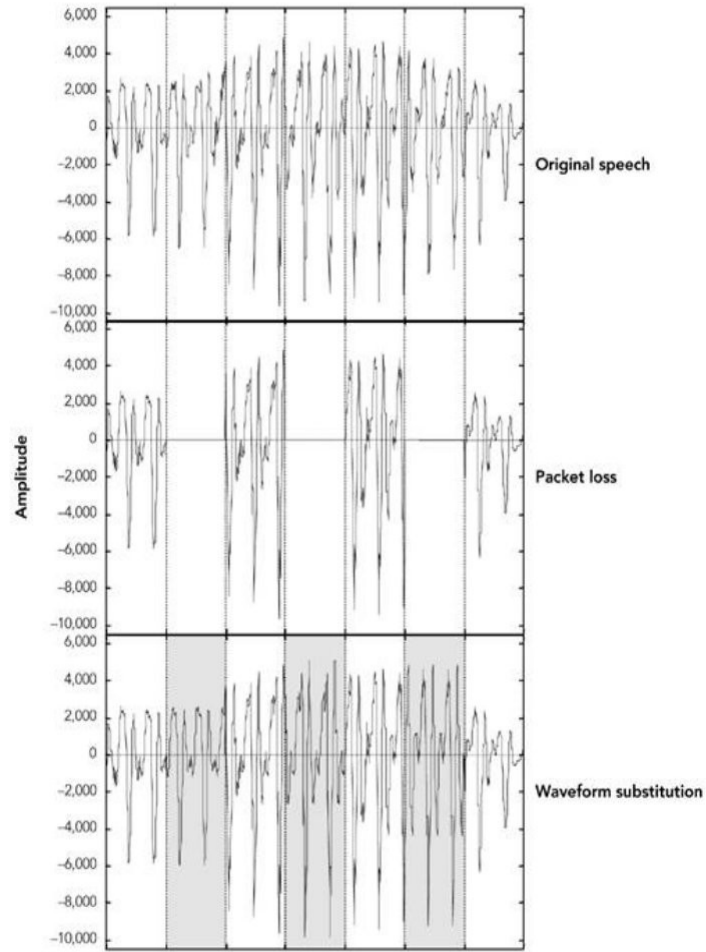
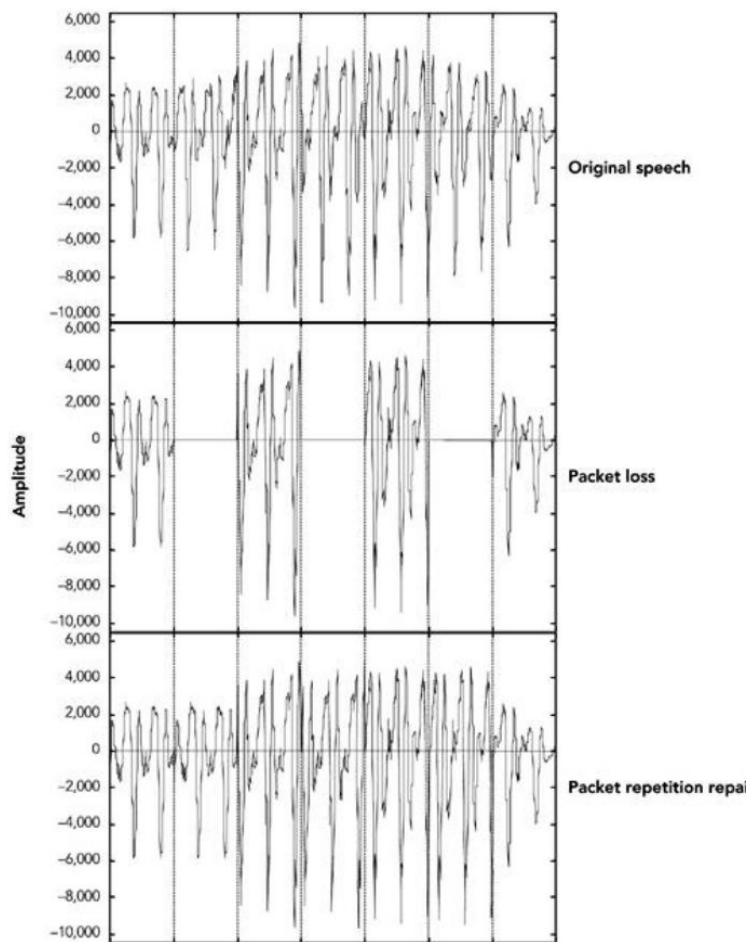


Error cancealement and correction

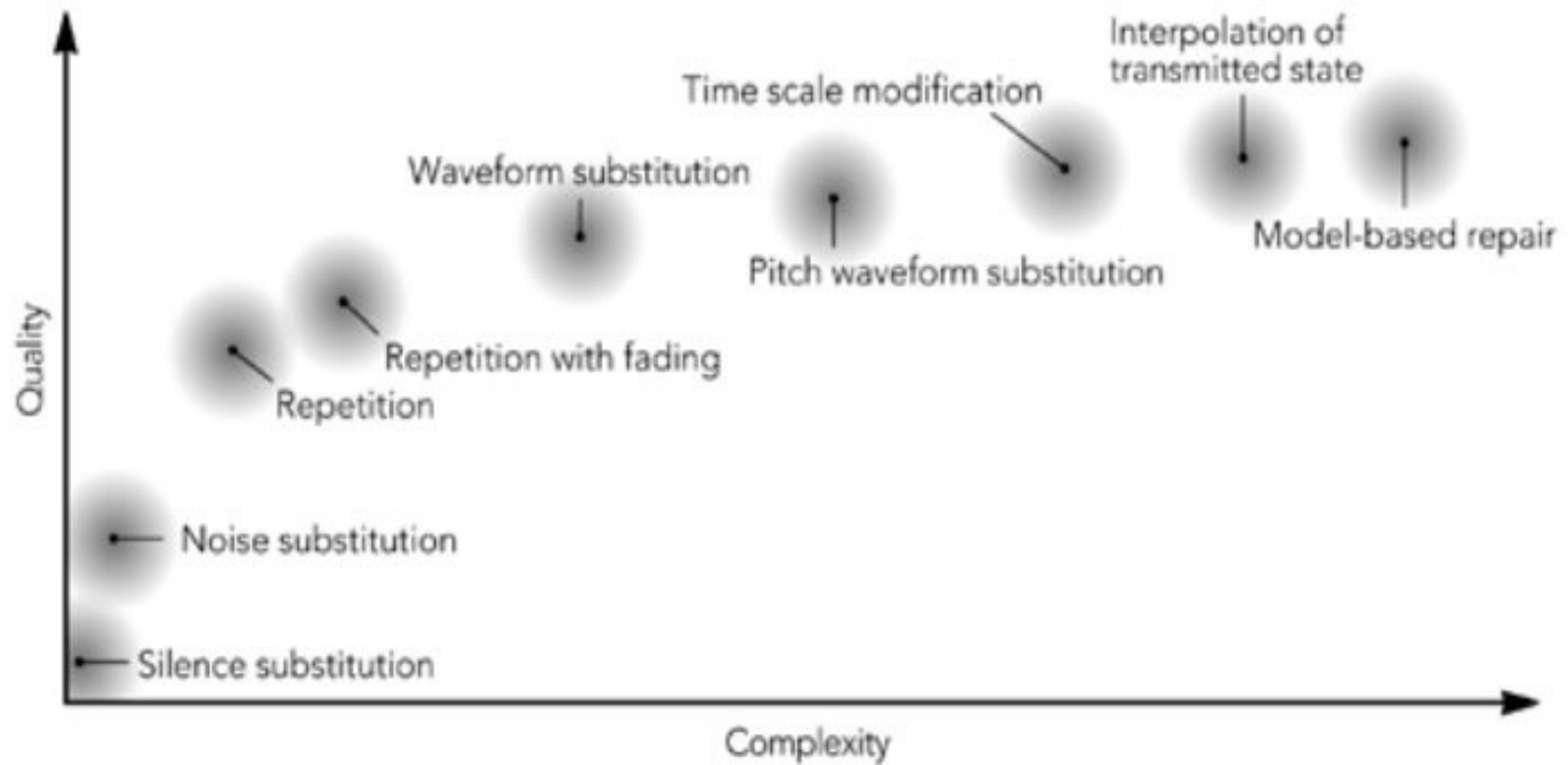
Speech error cancellation (1)



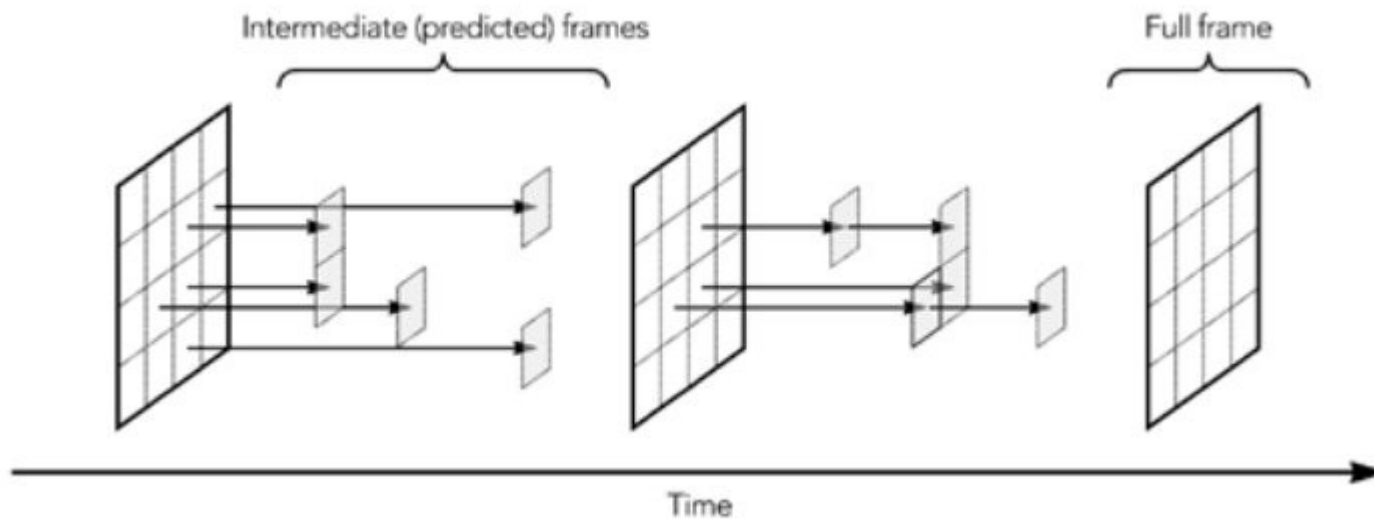
Speech error cancellation (2)



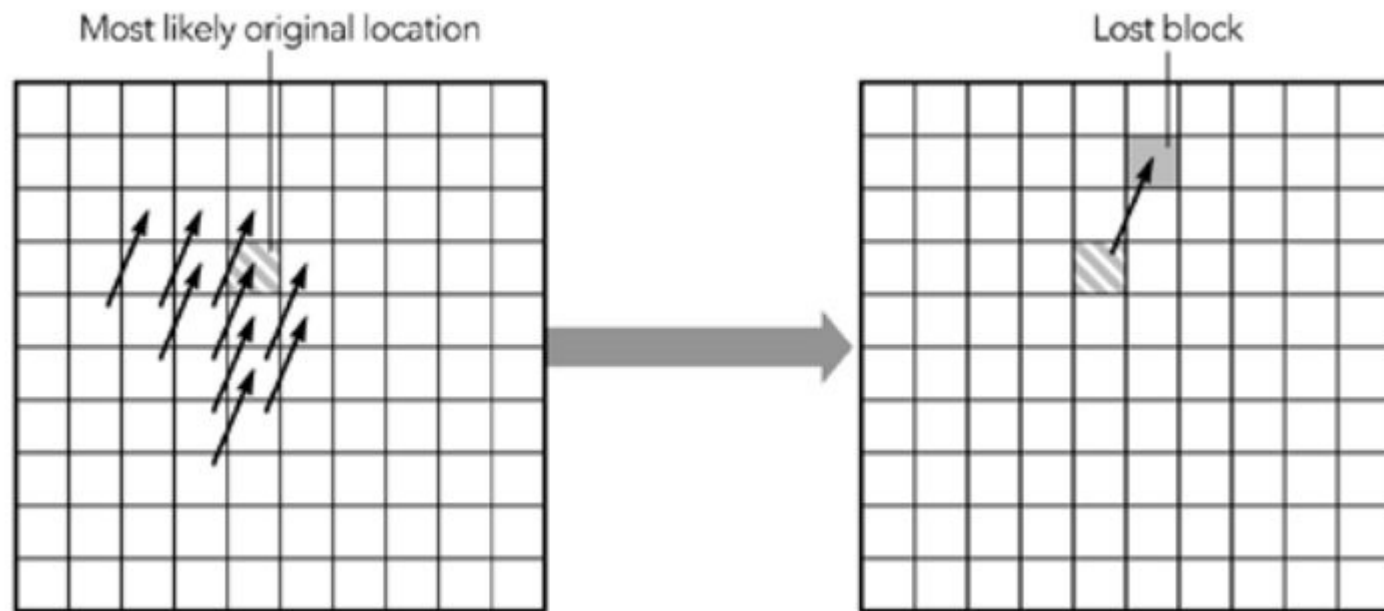
Error cancellation methods



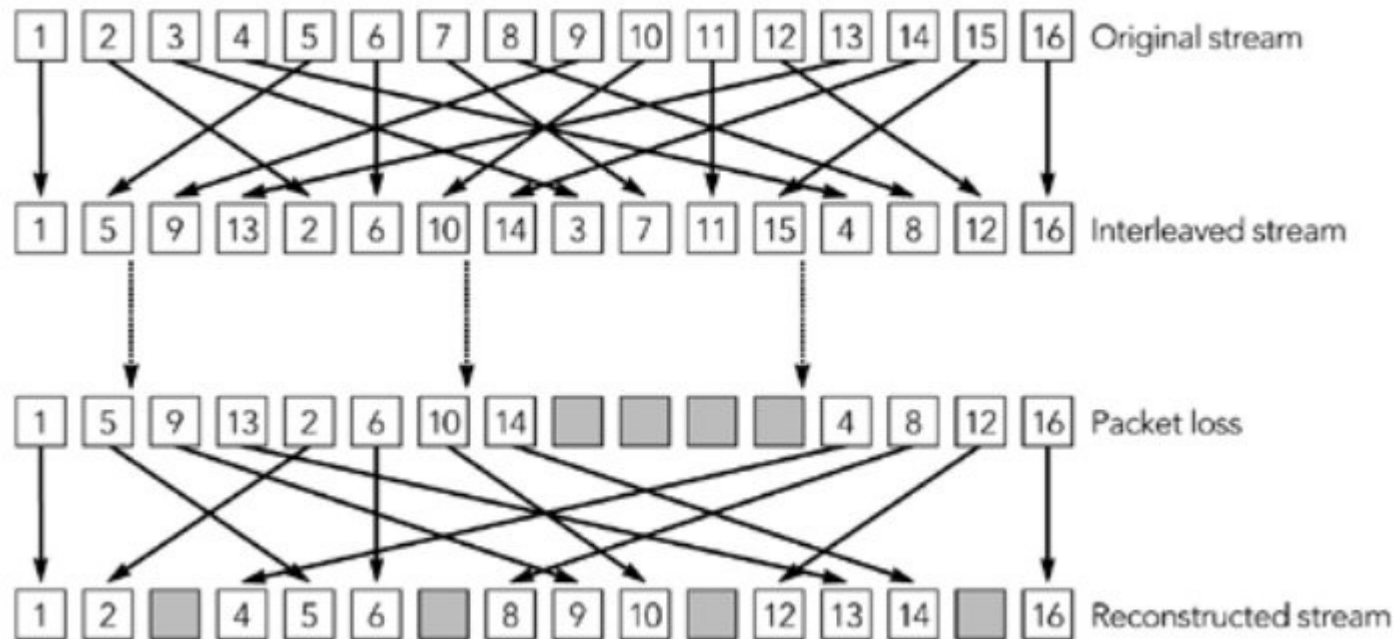
Video codec operation



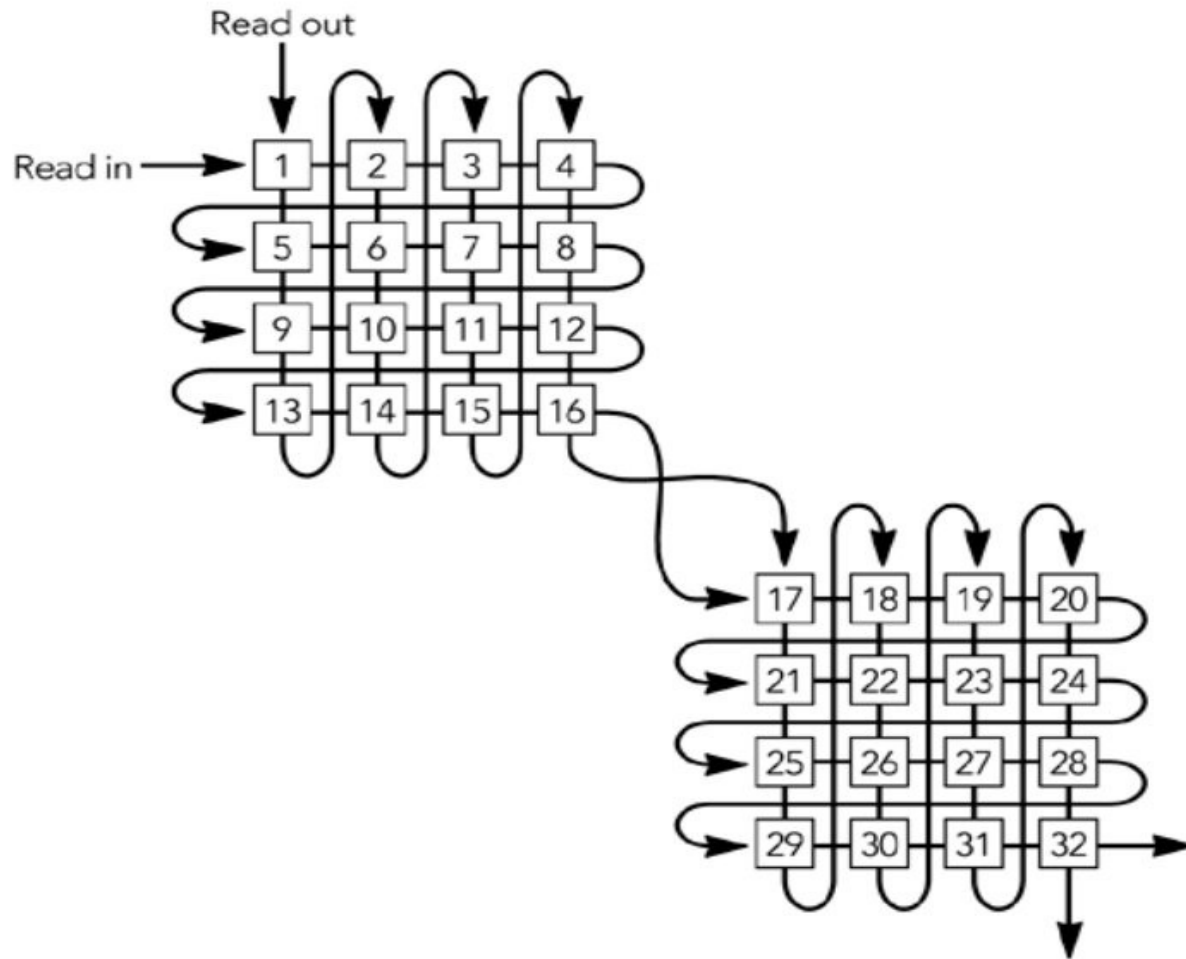
Video motion compensation



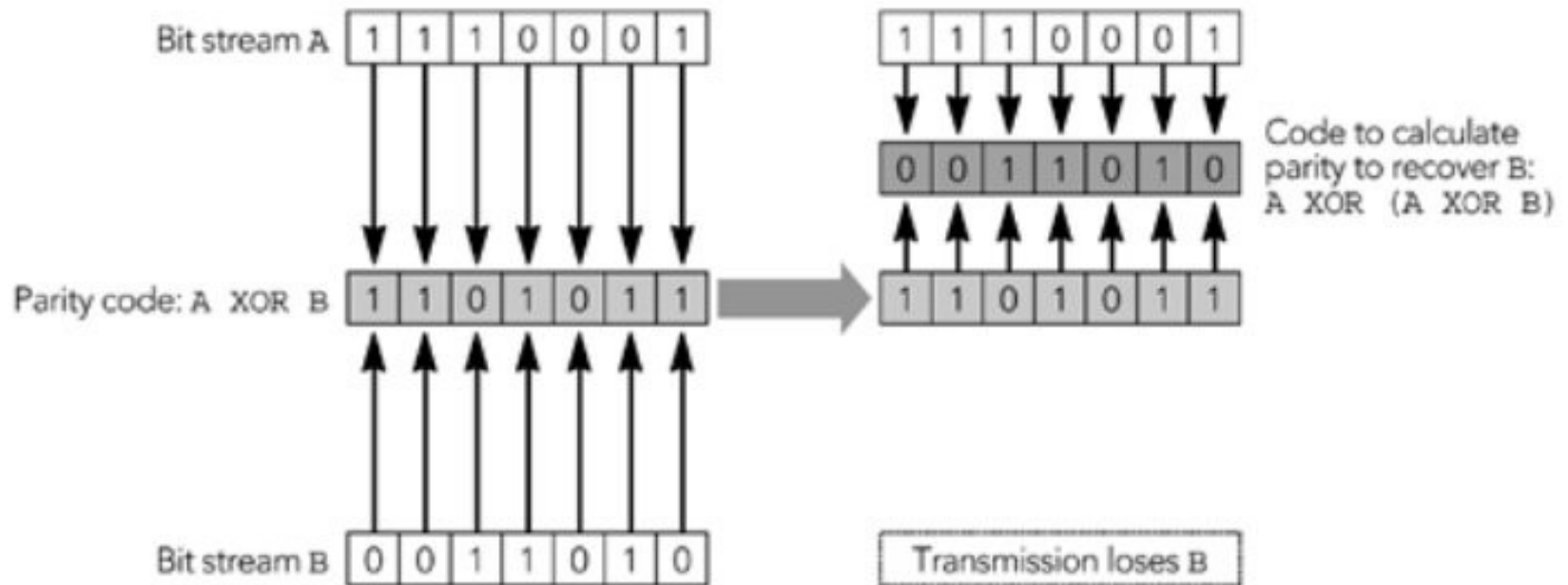
Packet interleaving



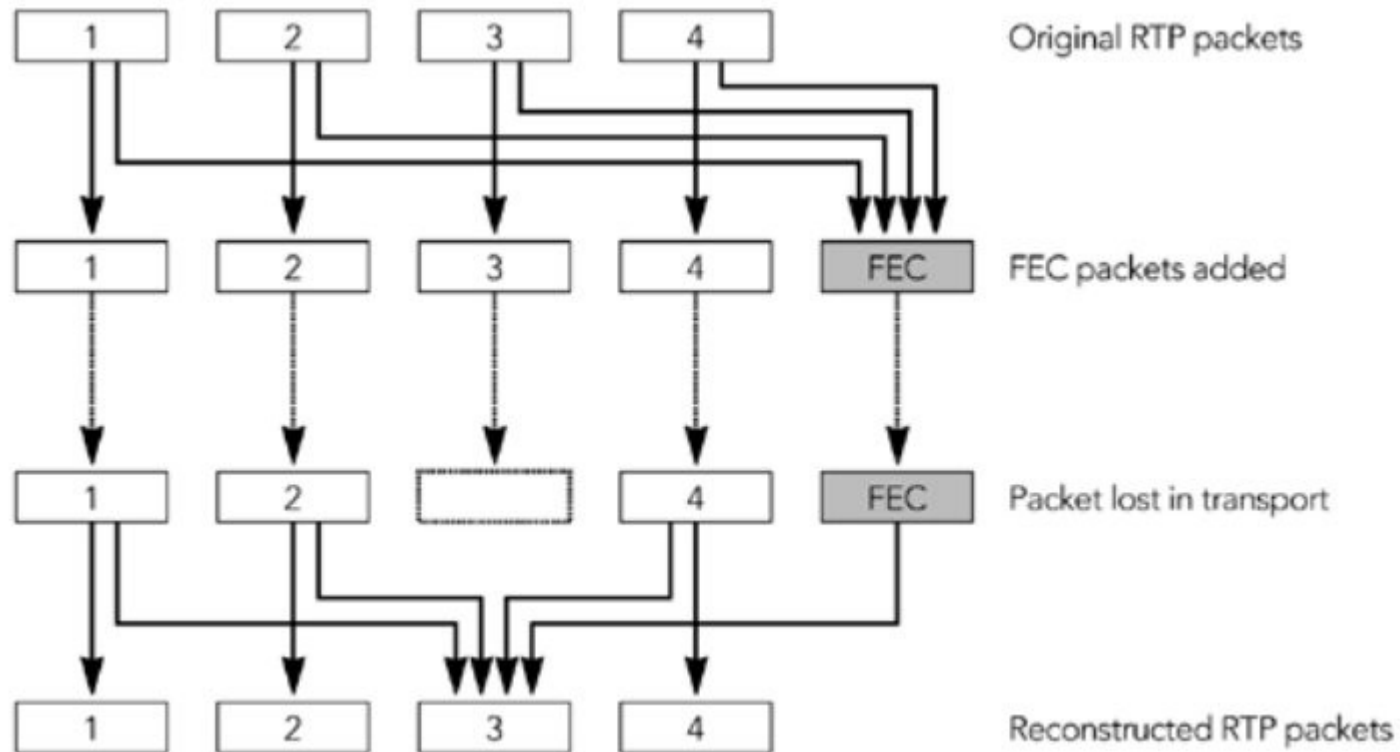
Interleaving matrix



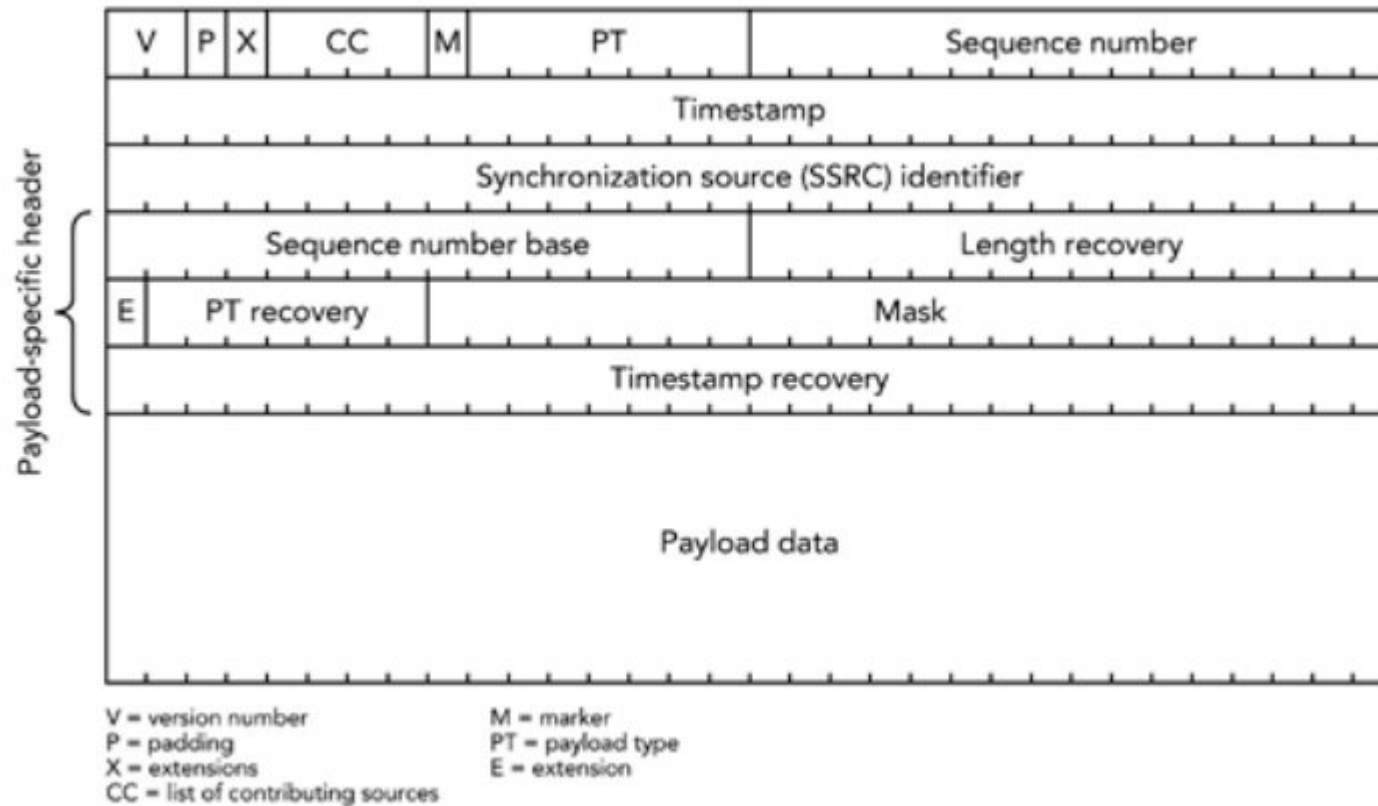
FEC – parity based error correction



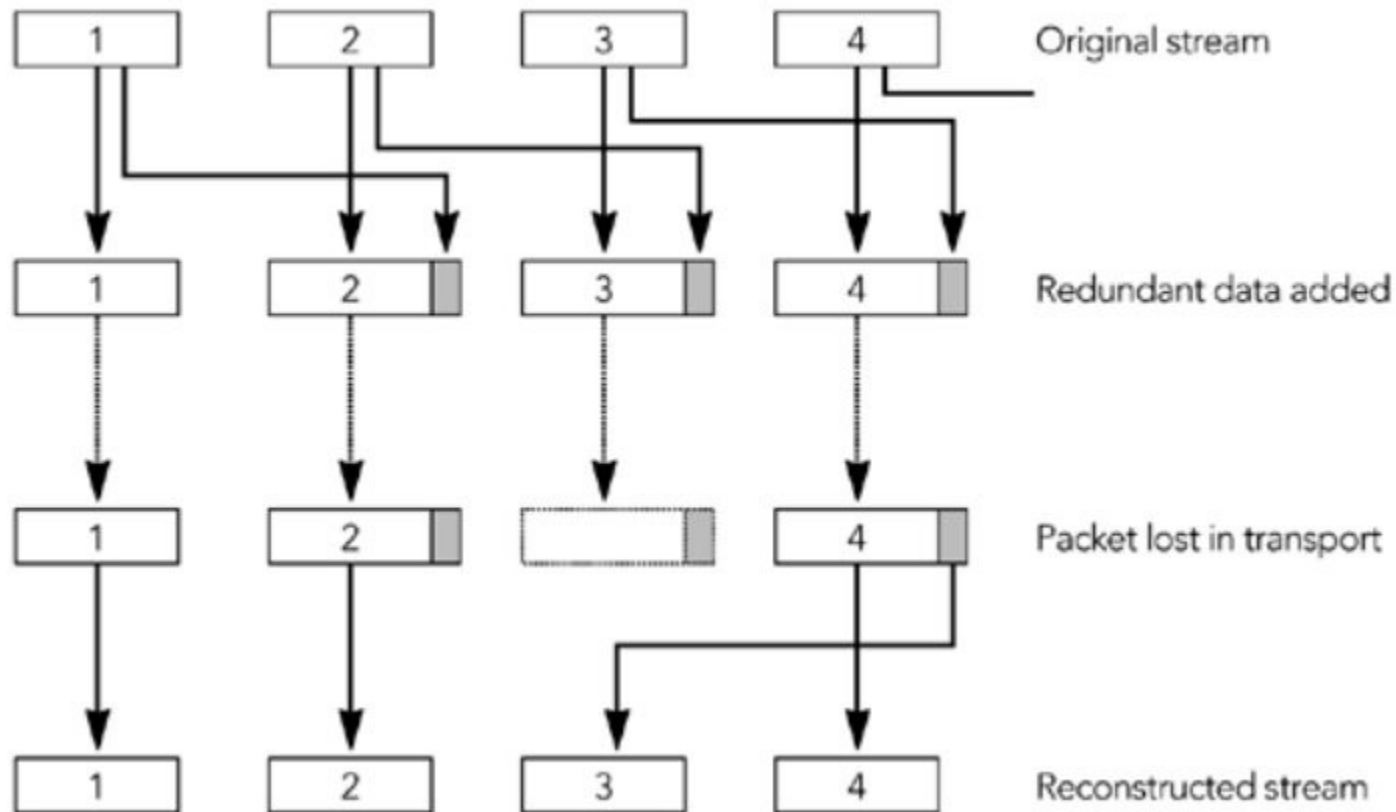
FEC – packet repair



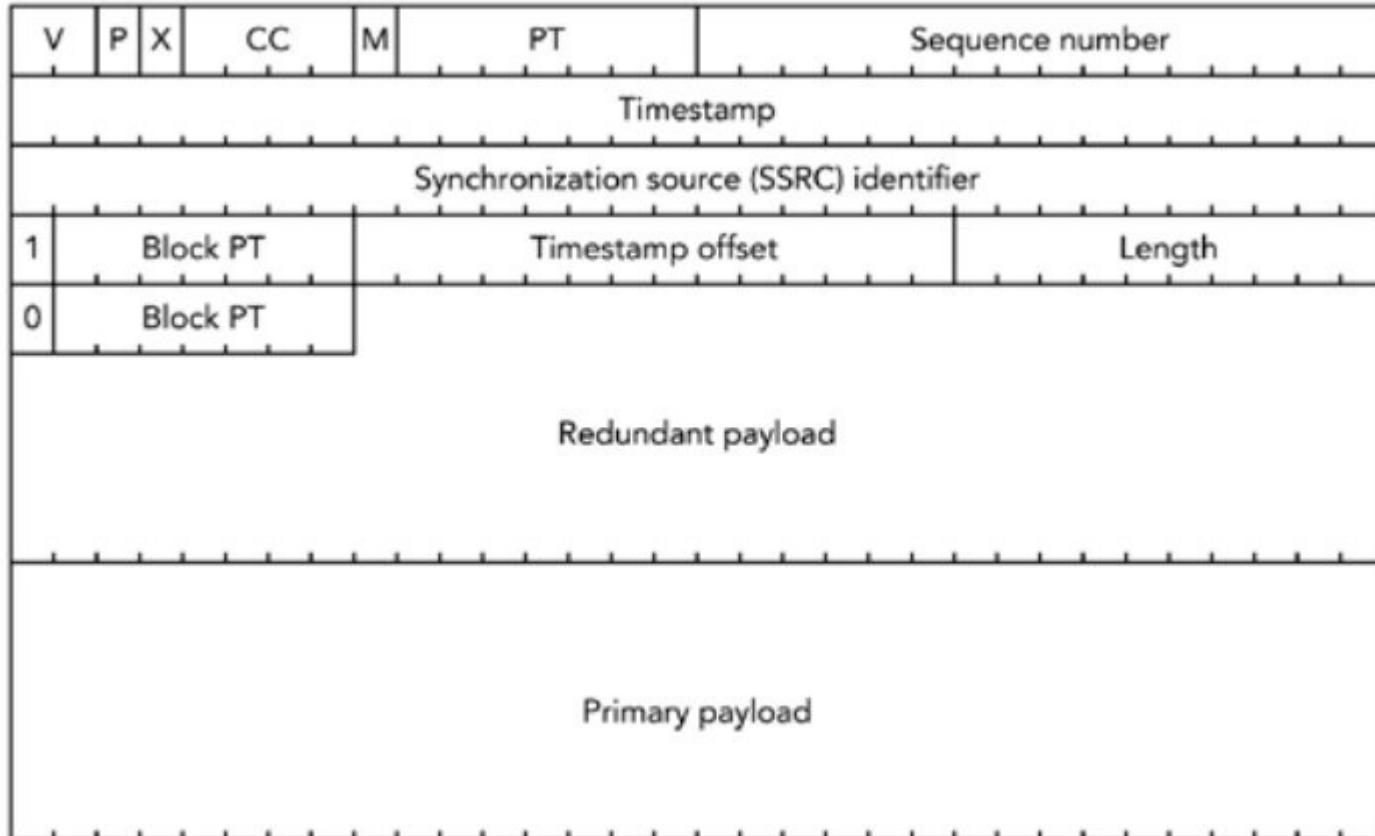
RTP - FEC packet repair



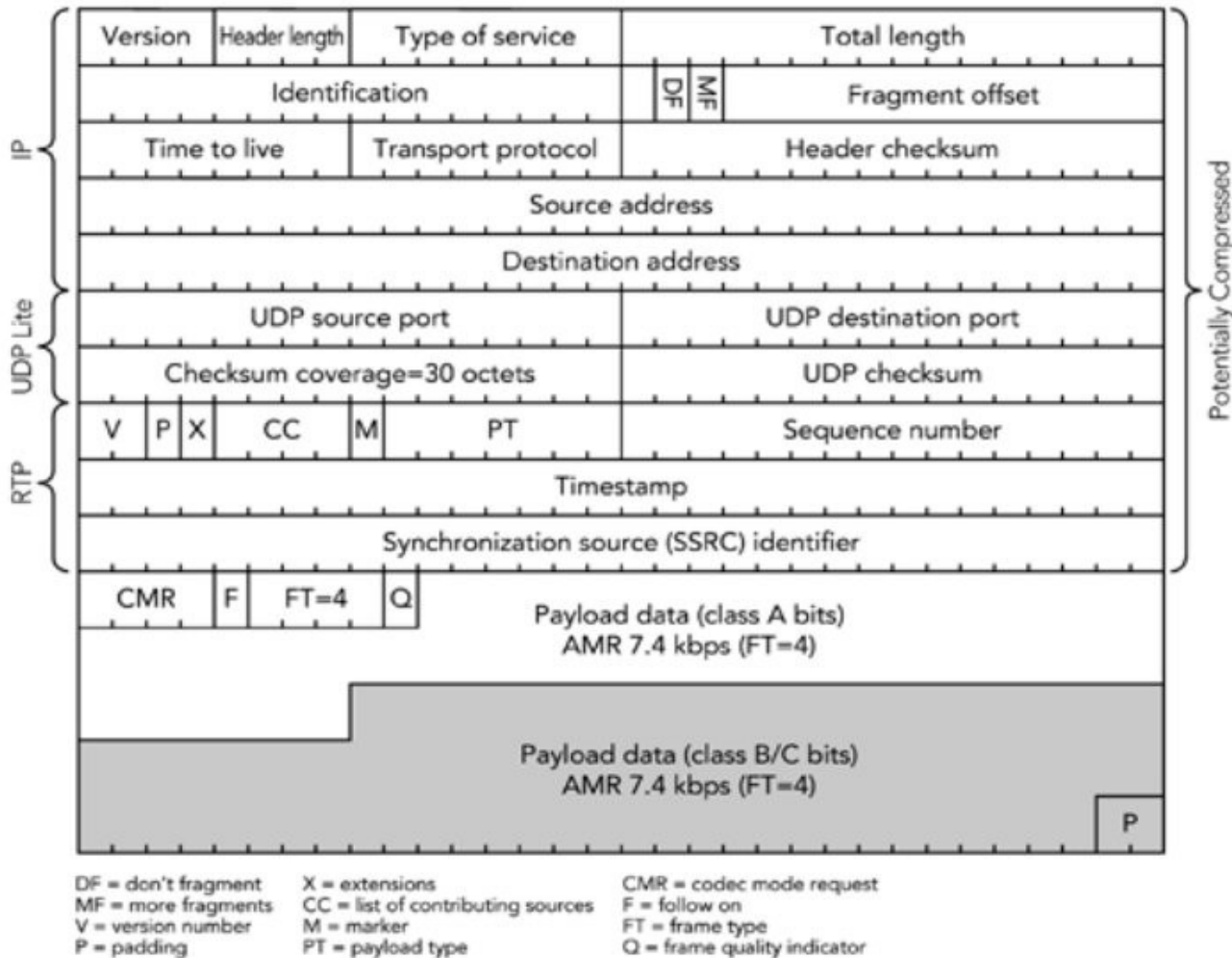
FEC – Redundancy coding



RTP - redundancy packet



RTP – partial checksum



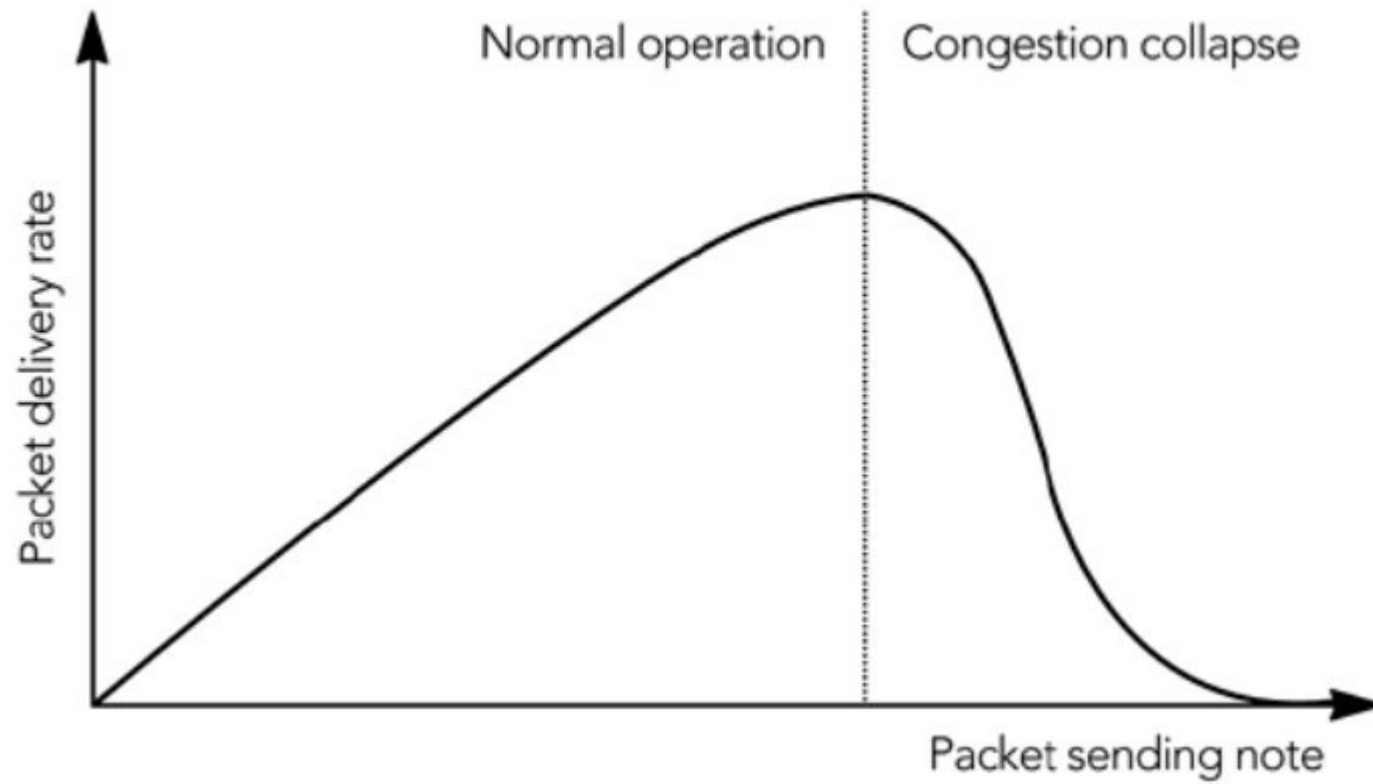
RTCP – transmission feedback

V	P	FMT	PT	Length
SSRC of packet sender				
SSRC of media source				
Packet identifier			R	Bitmap of lost packets/# packets

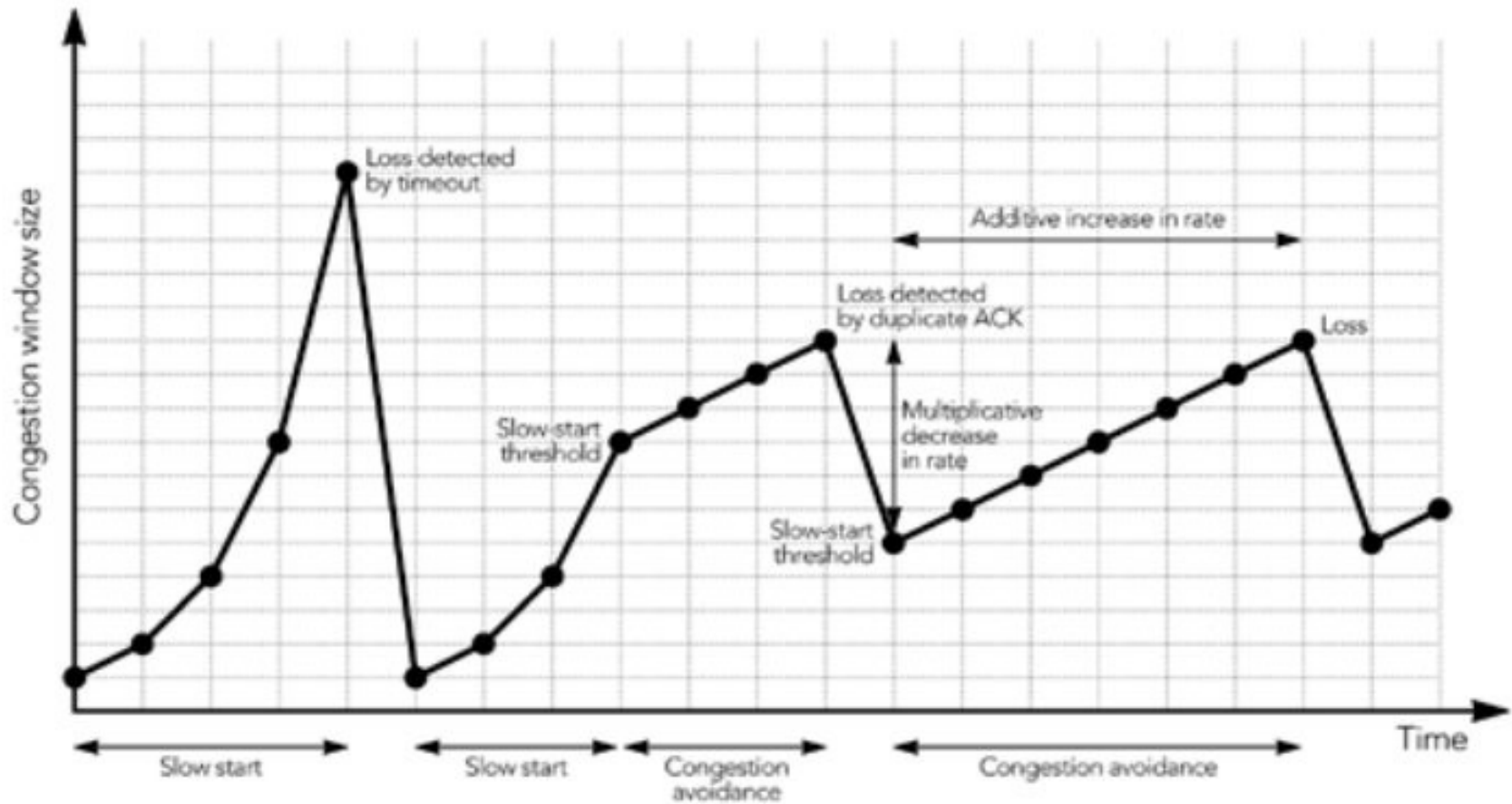
V	P	FMT	PT	Length
SSRC of packet sender				
SSRC of media source				
Packet identifier			Bitmap of lost packets	

V = version number
P = padding
FMT = feedback message type
PT = payload type

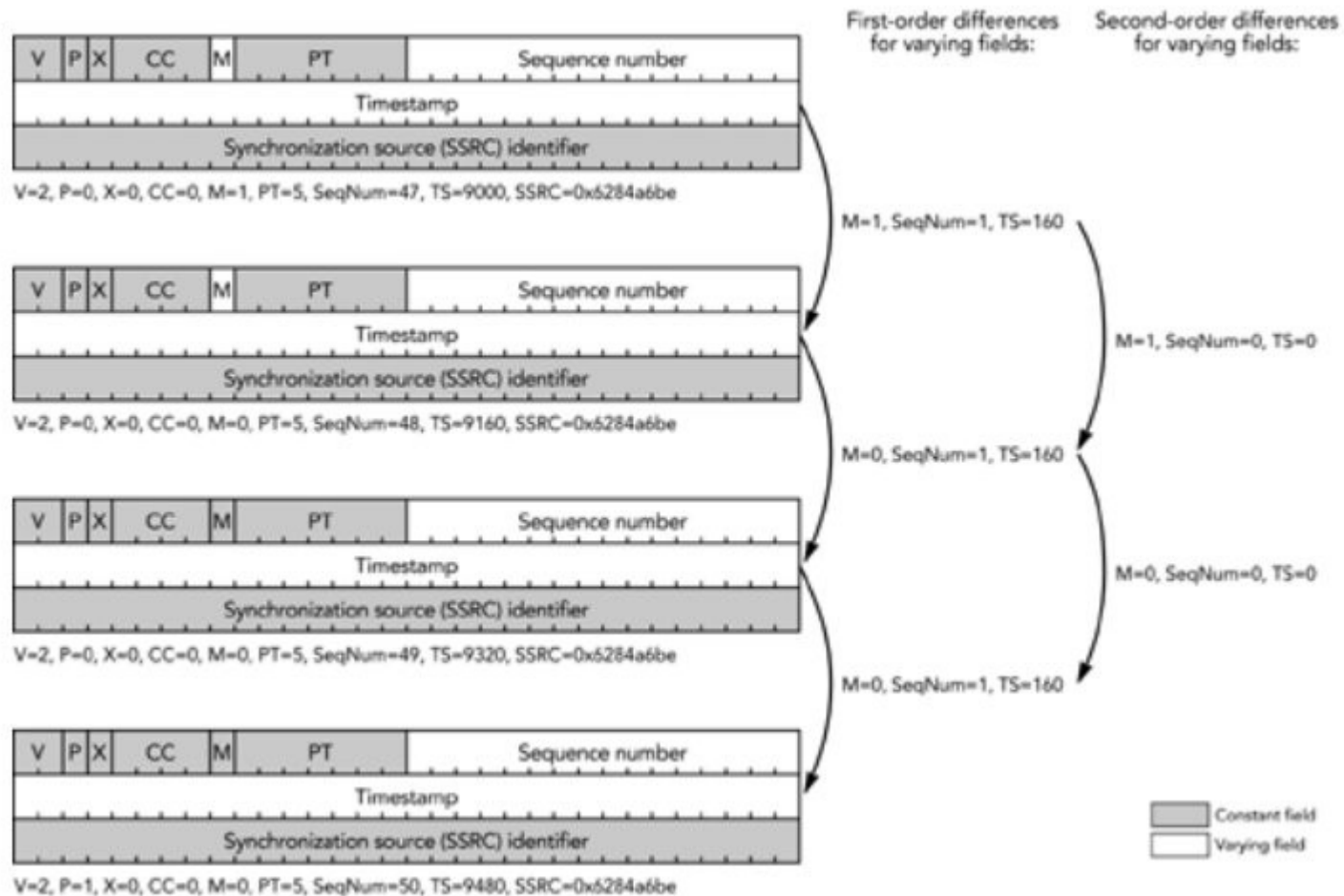
Congestion



Congestion control with TCP

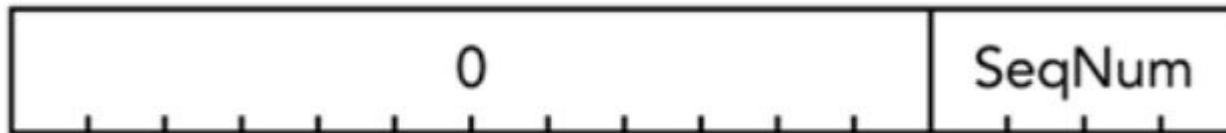
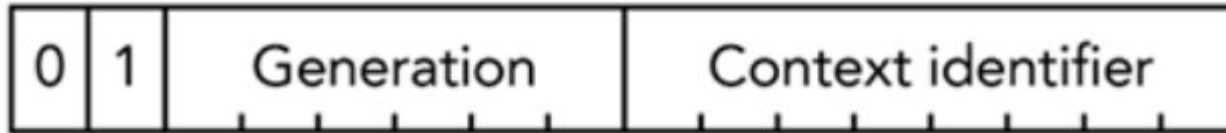


Header compression - principles

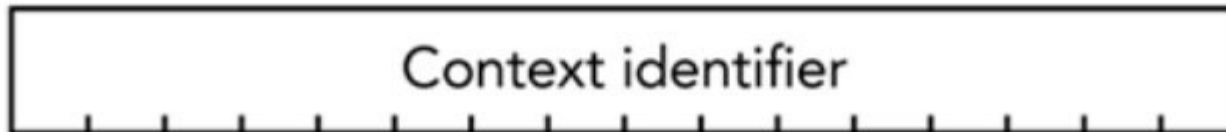
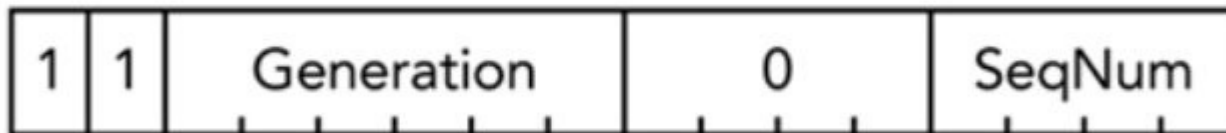




Header compression - option

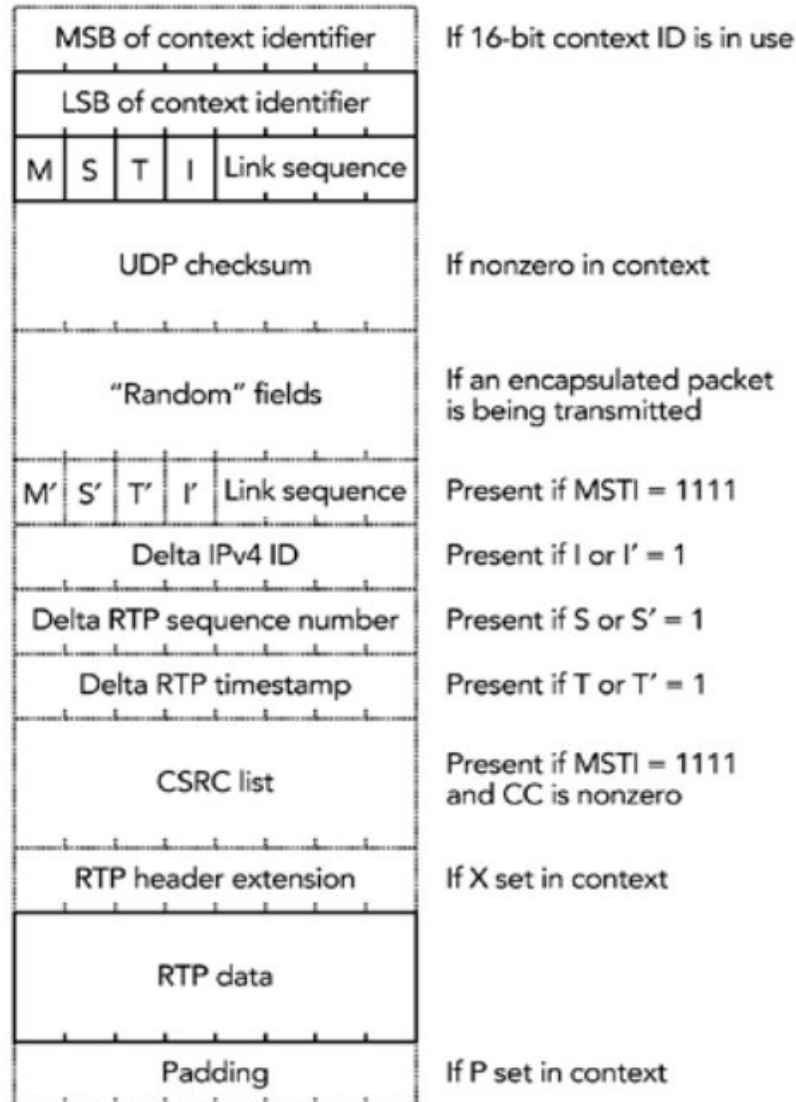


For 8-bit context ID



For 16-bit context ID

Compressed (header) RTP packet





Summary

- Multimedia protocol stack
- RTP and RTCP protocols
- Audio/video capture
- Media frames & packets
- Packet reception & play-out
- Media synchronization
- Error concealment and repair
- Congestion (TCP) and header compression