Media Transport in Packet Networks

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Why Not Use TCP?

- Four problems
  - » *No need for 100% reliability*
  - » *Slow start*
  - » *Retransmission delay*
  - » *Window backoff*
  - » *N participants -> N*N connections*
  - » *So use UDP and IP multicast*

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Need for RTP

- Loss, out of order: sequence number
- Loss, jitter: timestamp
- Source/payload identification
- Rate control: QoS feedback
- RTP provides functions to support these requirements for many real-time applications

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RTP: de facto standard

- End-to-end transport of real-time data, such as audio and video; and data for non-real-time applications
- Does not guarantee QoS

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- Does not address resource reservation along the path of a connection
- Requires the use of signaling protocol to set up the connection and negotiate media format to be used

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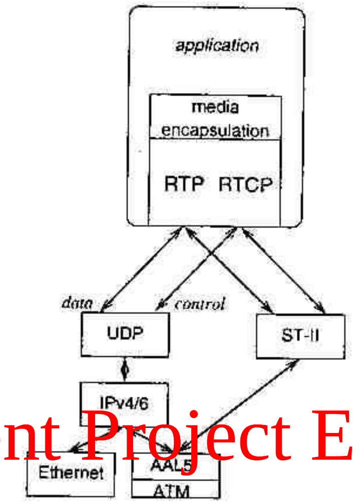
- RTP is enhanced with RTCP which is part of the RTP specification
  - » *RTCP provides for end-to-end monitoring of data delivery and QoS*
- Independent of the underlying transport and network layers
  - » *most commonly used on UDP*
    - –RTP assigned an even UDP port number
    - –RTCP assigned the next higher UDP port (odd)
- Supports multiple destinations if network supports multicast distribution

RTP – the big picture



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Data transport – RTP

Real-Time Transport Protocol (RTP) = data + control

data: timing, loss detection, content labeling, talkspurts, encryption

control: (RTCP) ➠ periodic with $T \sim$ population

- QOS feedback
- membership estimation
- loop detection

Packet based delivery – basic issues

- Store and forward handling in routers – delay
  - » *IP switching (hardware technology) to reduce intermediate packet delays*

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- High protocol overhead (RTP over UDP over IP over ATM) – extra bandwidth requirement
- To achieve bandwidth savings –
  - » *Header compression often prescribed and used*
  - » *statistical multiplexing – mixing of voice and data packets*
- Problem – not backward compatible with existing routers
  - » *new router designs*

Packet based delivery – basic issues

Uncompressed RTP/UDP/IP header = 12+8+20 = 40 bytes

Encapsulation overhead for ATM (RFC1483) = 8 bytes

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Payload = N bytes per packet

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» *this represents an entire ATM cell of 48 bytes + an ATM header of 5 bytes before first byte of payload is transmitted*

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Minimum of 2 ATM cells is required for a single voice sample

Using header compression (RFC2809) 40 bytes is reduced to 2 bytes

Voice over RTP bandwidth calculations

Payload format	Nominal rate	Packet rate (ms)	Payload size (bytes)	Required BW (Kbps)	
				uncompressed	compressed
G.711	64 Kbps	20	160	80	64.8
G.711		10	80	96	65.6
G.729	8 Kbps	20	20	24	8.8
G.729		10	10	40	9.6

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- Packet rate is the frequency with which packets are formed and transmitted – either 10 ms or 20 ms for most applications
- Bits per 20 ms packetization interval for G.711 over RTP/UDP/IP/Encaps/AAL5 = minimum 5 ATM cells = 53*5 bytes = 2120 bits

- **Compressed packet headers –**

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  - **additional computational requirements in intermediate routing nodes**

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  - **major issue with user multiplexing and stream mixing at intermediate points**

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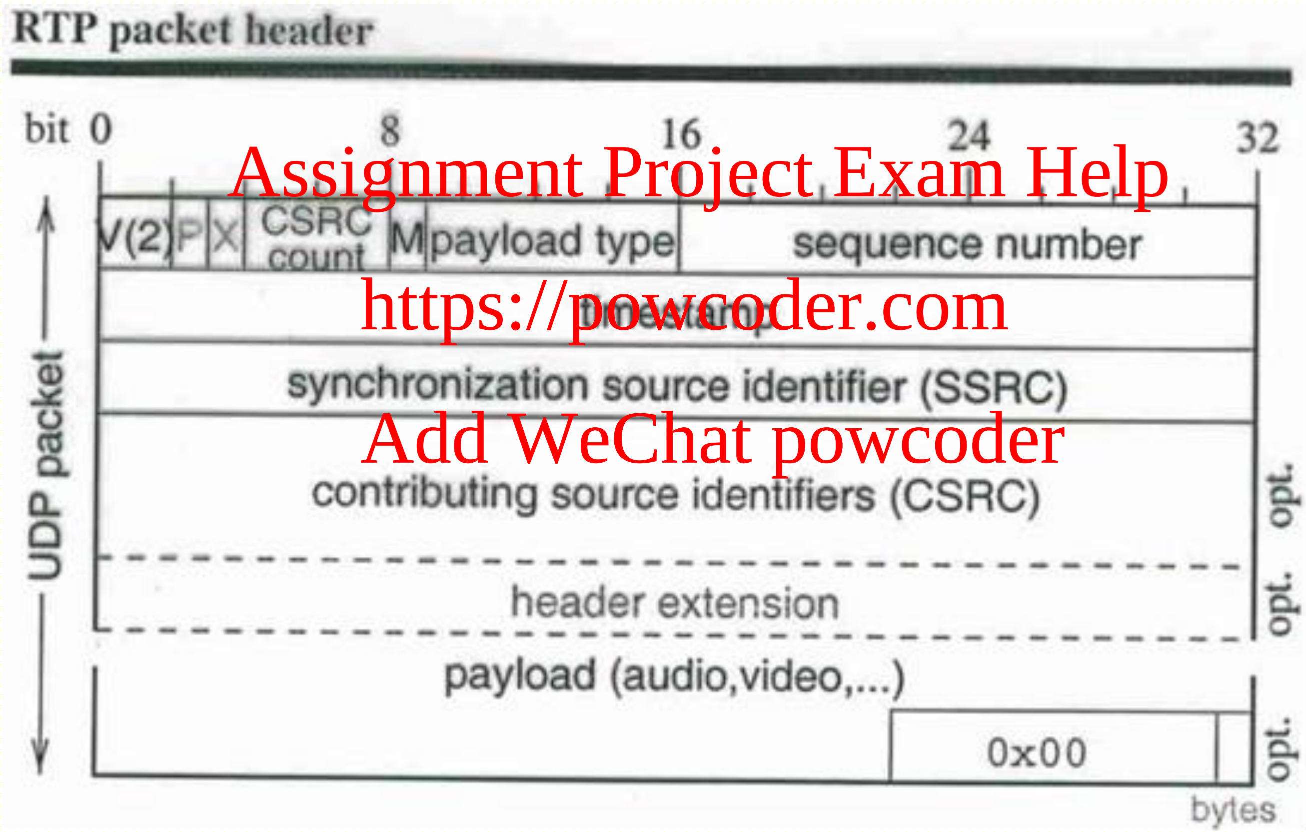
  - **header expansion and interpretation at intermediate nodes can be lengthy process – adds to end-to-end delay**

RTP packet



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RTP packet header

- Version (V, 2 bits)
- Padding (P, 1 bit) – for encryption with fixed block sizes
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  - if set, last byte of the padding contains a count of how many padding bytes should be ignored
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- Extension (X, 1 bit) –
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  - if set, the fixed header is followed by exactly one header extension (2 bytes) to pass control information not to be interpreted by intermediate nodes
- CSRC count (CC, 4 bits) – for mixers
  - number of contributing sources to this packet
  - if only one SSRC in the stream, CC = 0

RTP packet header

- Marker (M, 1 bit) – to mark frame boundaries
  - signifies the beginning/end of a talk spurt (to begin playout of comfort noise), or end of a video frame.

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- Payload Type (PT, 7 bits) – format of RTP payload (e.g. G723)

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  - once a session is set up, a sender cannot use different RTP payloads during the session
- Sequence Number (16 bits) – +1 for each packet
  - used by receiver to detect packet loss and to restore packet sequence
  - packet reordering very hard to do – costs in voice/video quality

RTP packet header

- Timestamp (32 bits) – random starting value
  - increments by one for each sampling period for fixed-rate audio
    - If an audio application reads blocks covering 160 sampling periods from the input device, the timestamp would be increased by 160 for each such block

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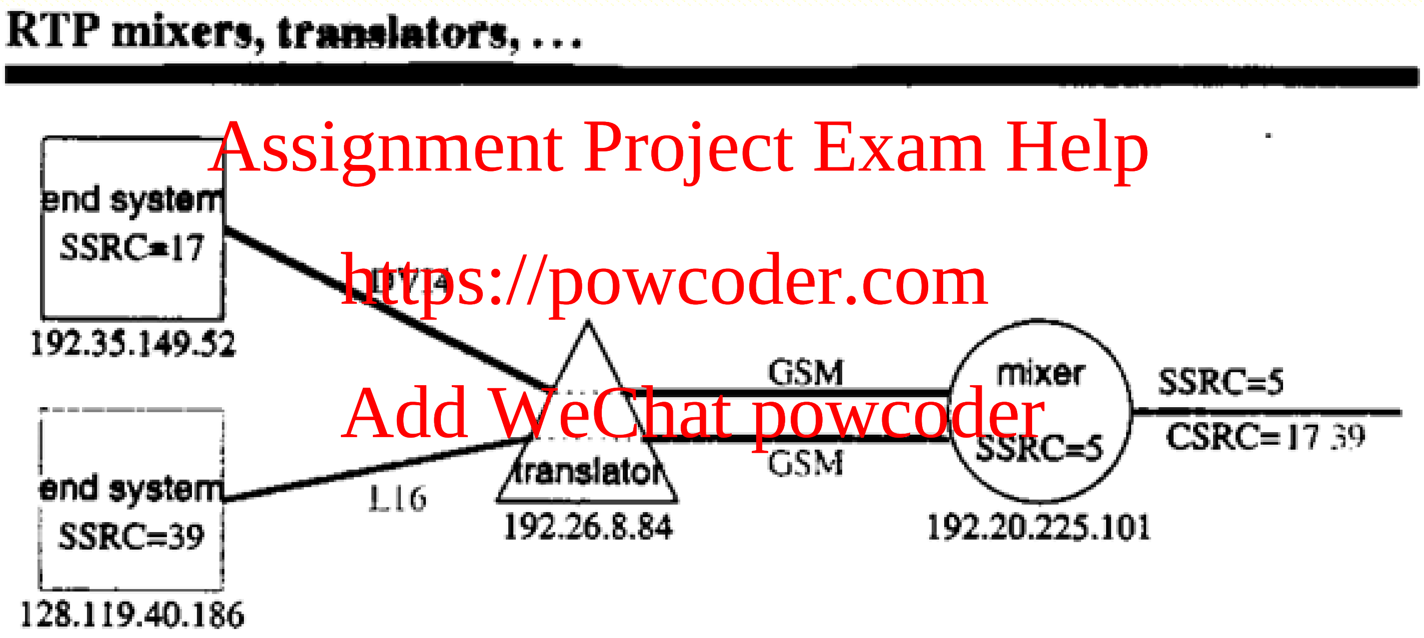
- SSRC (32 bits) – identifies synchronization source (sender)
  - value chosen randomly – no two senders have same SSRC identifier
  - collisions resolved by simple mechanisms in RTP
- CSRC list (0 to 15 items, 32 bits each) –
  - identifies contributing sources for payload contained in this packet
  - used for correct source identification when payloads played out at endpoint

Mixers and Translators



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RTP mixers, translators, ...

mixer:

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- several media stream ⇒ one new stream (new encoding)

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- mixer: reduced bandwidth networks (dial-up)
- appears as new source, with own identifier

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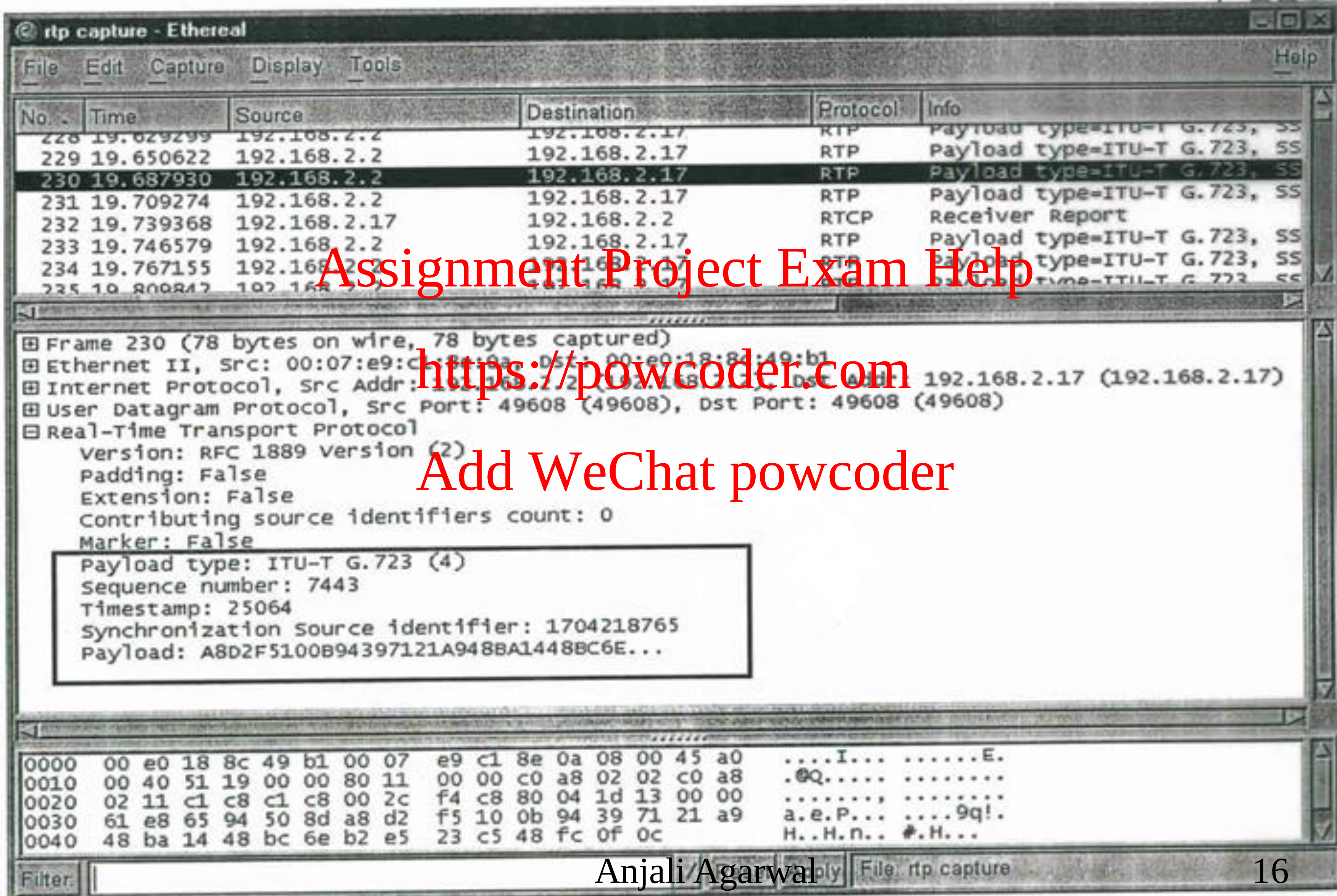
translator:

- single media stream
- *may* convert encoding
- protocol translation (native ATM ↔ IP), firewall
- all packets: source address = translator address

RTP Packet



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IMPLEMENTATIONS OF RTP OVER THE INTERNET

"Internet telephones" (usually for PCs) available using proprietary audio coding and protocols, meant for point-to-point connections:

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- Speak Freely for Unix and Windows
- Vocaltec Internet Phone)
- SoftFone by SilverSoft
- Digiphone
- Quarterdeck
- Internet Telephone Company
- Telescape Intercom by Telescape
- IBM Internet Connection Phone
- CuSeeMe (for Windows PC and the Macintosh)
- IRIS
- Lucent 4111 Multifunctional DCP Voice Terminal
- Audio/video directly over ATM: Nemesys
- FreeVue audio and video
- NVAT
- Ericsson LAN Phone
- RealAudio (Microsoft Windows only)
- AudioSoft
- VDO

Real Time Control Protocol (RTCP)

- to convey end-to-end information about the quality of the session to each participant
  - » *like packet delay, jitter, packets received and lost are valuable to access network health in real-time*

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- Based on periodic transmission of control packets to all participants

- RTP and RTCP may or may not be routed on the same end-to-end path

RTCP packet format

- SR: Sender Report
  - » *for transmission and reception statistics from active sender participants*

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- RR: Receiver Report

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  - » *for reception statistics from not active senders*

ietf-avt-rtp-new-03.txt (work in progress)

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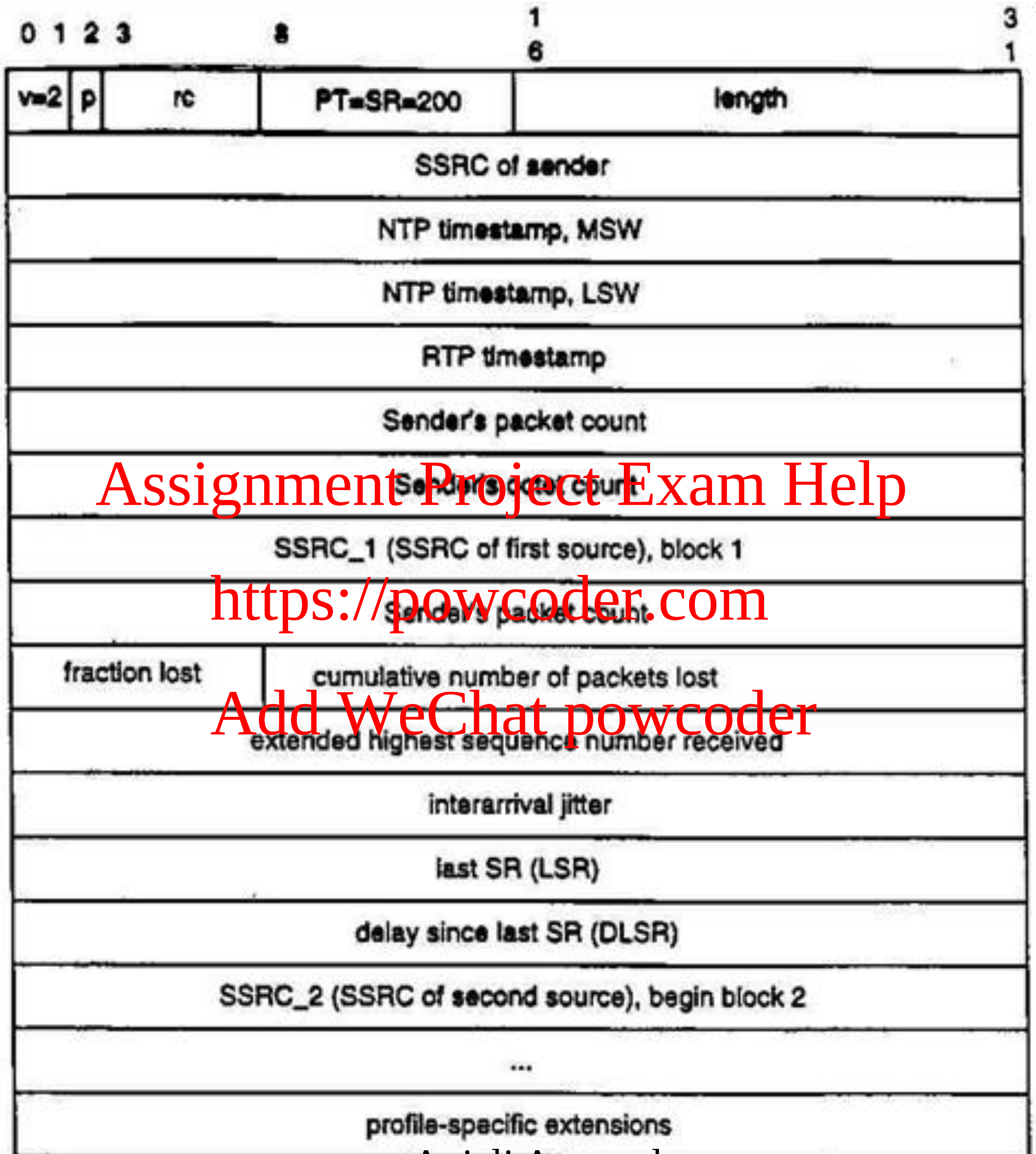
  - » *suggests 5%of session bandwidth be allocated for RTCP packets*
    - – 1.25% go to senders
    - – 3.75% be allocated to receivers



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RTCP Sender Report Packet Format

RTCP Sender Report

- SSRC of sender: identifies sending source of SR
- NTP timestamp: when report was send
- RTP timestamp: corresponding RTP time
- Sender's packet count: total RTP packets sent
- Sender's octet count: total octets sent
- rc: number of reception report counts (max 32) for which statistics are included in the packet
- FL: fraction of packets lost since last SR was send
- Cumulative packets lost: since beginning of session
- Highest sequence number received from SSRCn
- interarrival jitter as measured at the receiver
- LSR: time last SR heard
- DLSR: delay since last SR

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RTCP Receiver Report

- Conveys identical information as SR except sender information
- An endpoint can send RR or SR but SR contain overall packet and byte counts not reported in RR.

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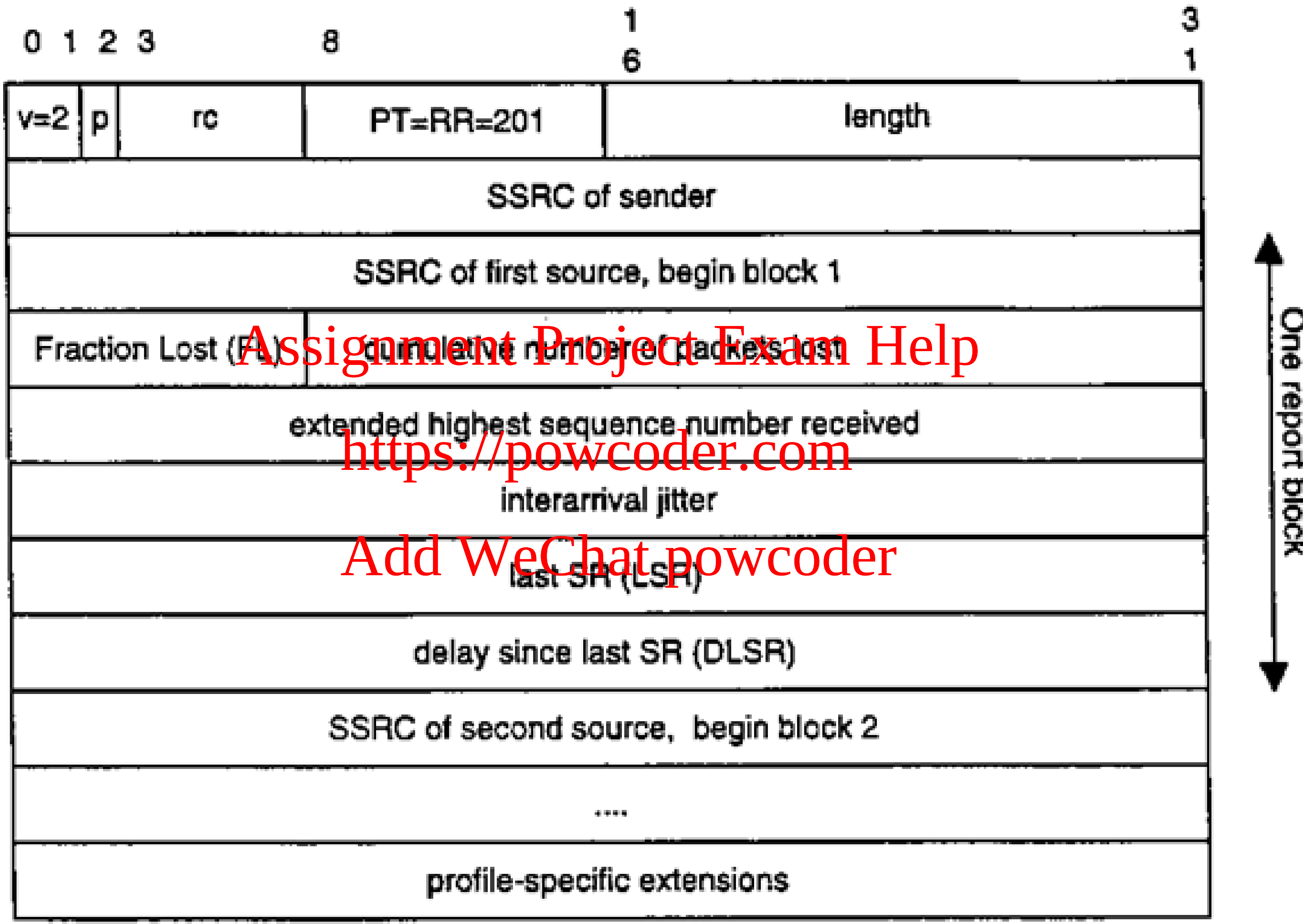

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RTCP Receiver Report Packet Format

RTCP packet format

- SDES: Source DEScription
  - » *binds SSRC in RTP with actual user identification*
    - – user's name, email address, login ID
    - – optional items as telephone #, user location
  - » *send at beginning of the session to explicitly identify each participant*
- BYE: ends user participation in a call
  - » *tells all participants that sending user is departing*
  - » *should contain the reason for statistics*
- APP: application specific RTCP packet
  - » *none yet (work in progress)*

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RTCP SDES packets

- binds an SSRC to sender's real identification
- up to 32 participants identified
- SDES items contain item id, length of item, and item itself
- Only 8 SDES items currently proposed

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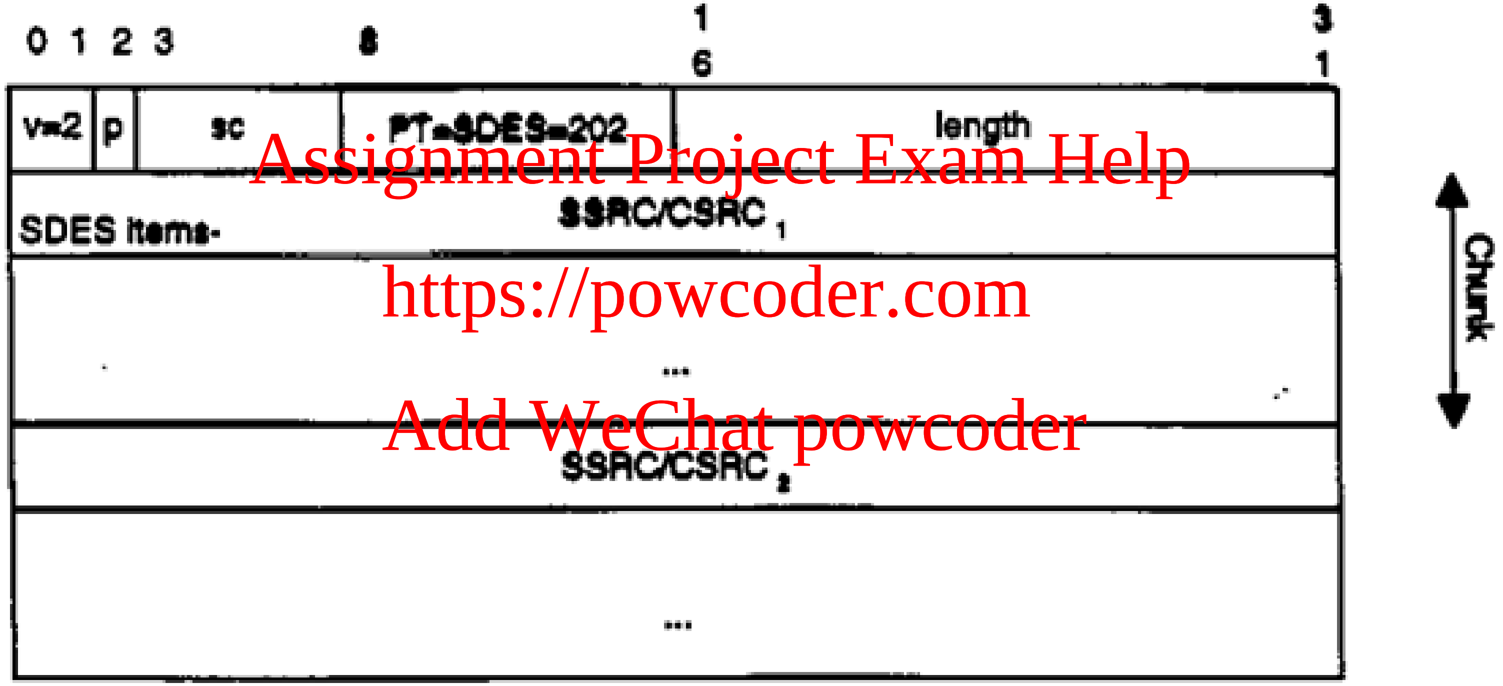

RTCP Source Description (SDES) Packet Header

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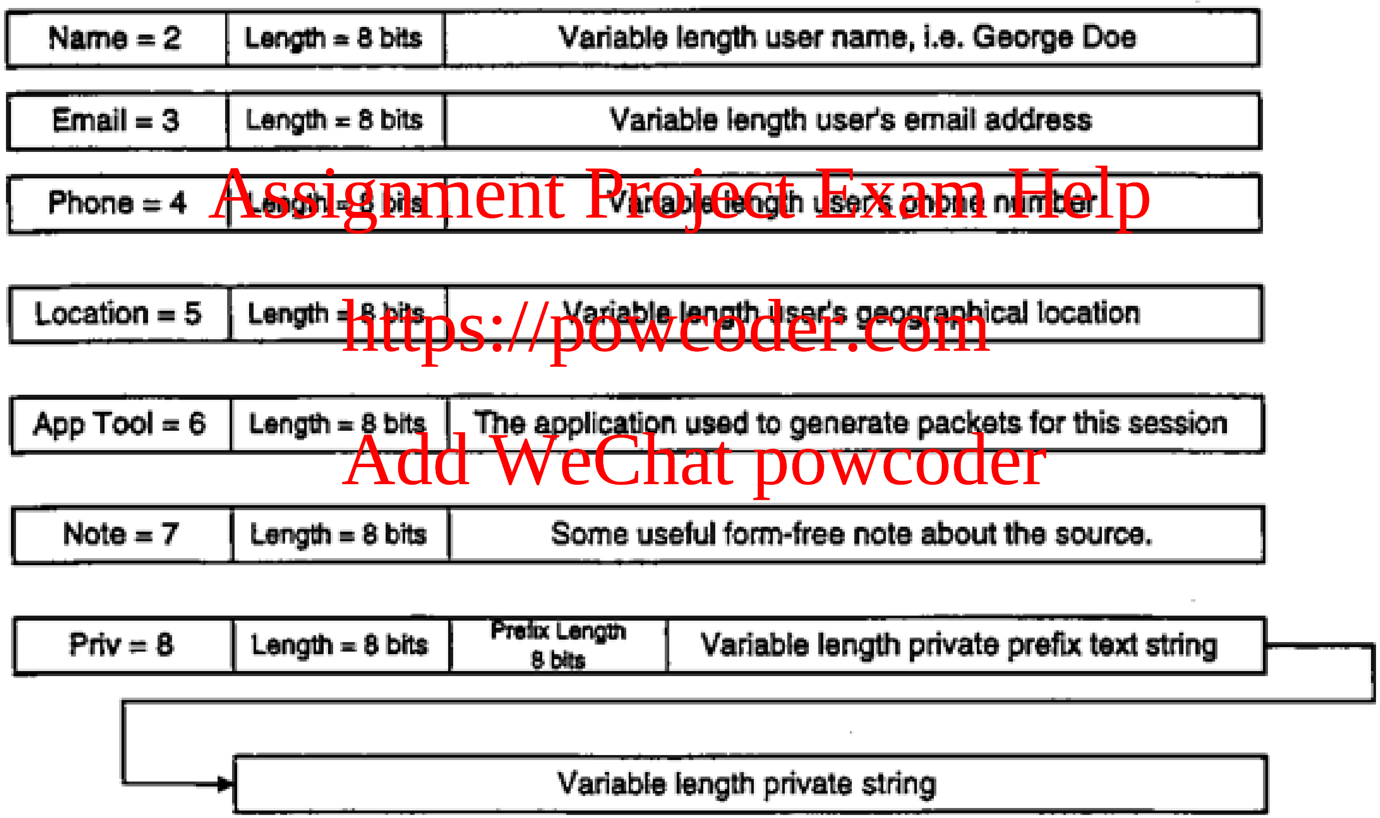

SDES Item Description

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Bye packet

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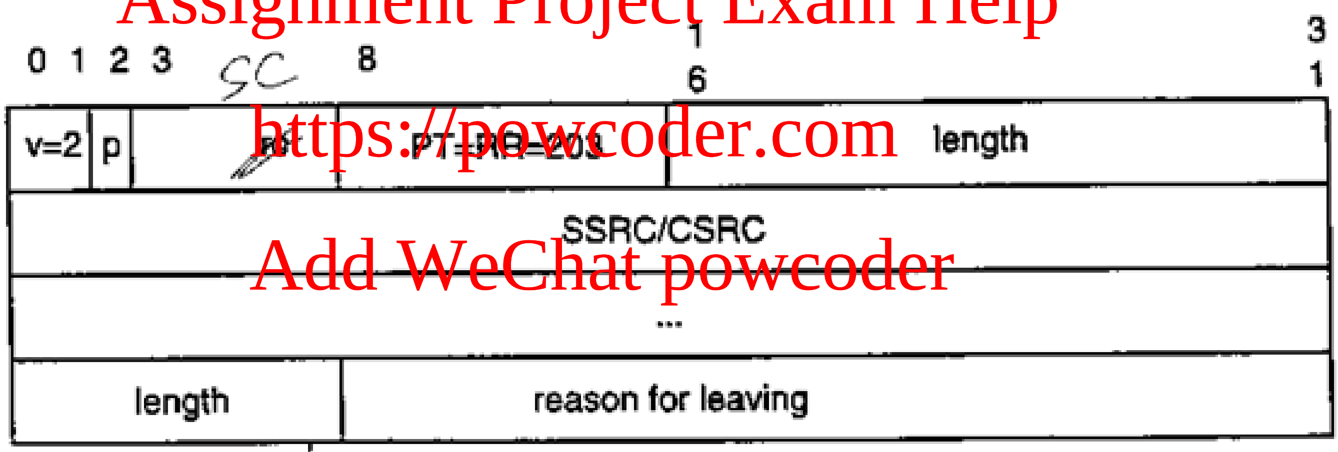
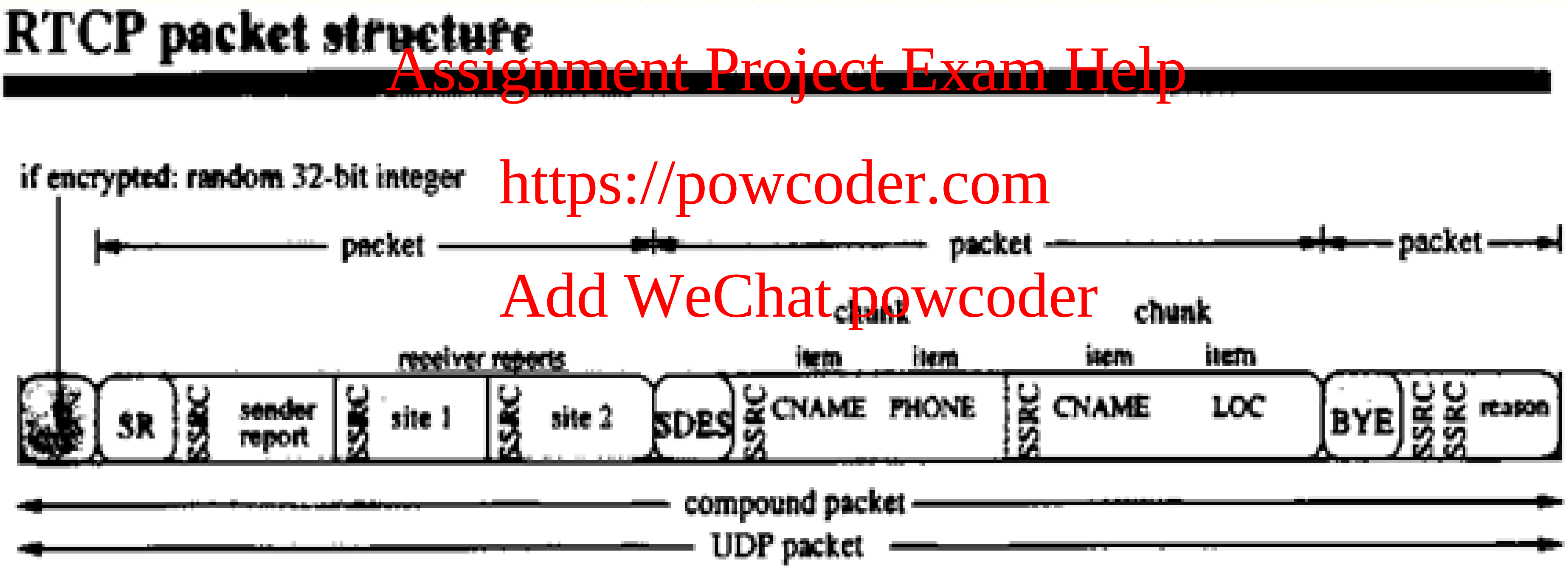


RTCP BYE Packet

RTCP packet



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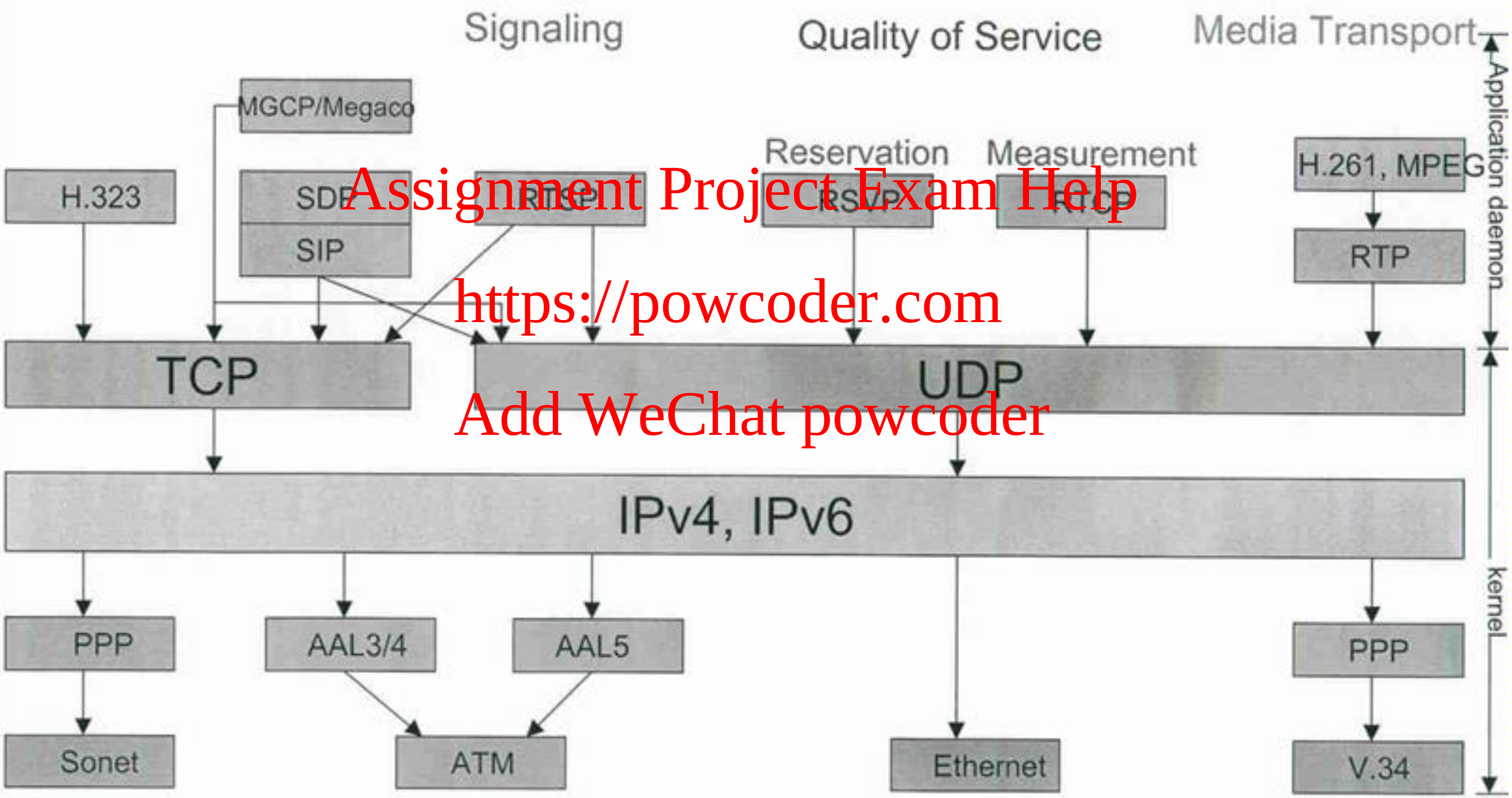
Multimedia protocol stack



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