Advanced Networking

Voice over IP:
RTP/RTCP – The transport layer

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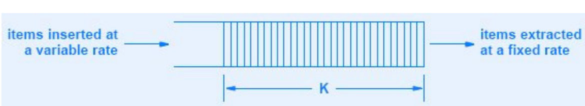
Requirements For Real-Time Transmission

- Need to emulate conventional telephone system
  - *Isochronous* – output timing same with input timing
- IP Internet is **not** isochronous!
- Additional protocol support is required:
  - *sequence information* that allows detection of duplicate or reordered packets
  - each packet (indeed sub-part of it) must carry a separate *timestamp* that tells the receiver the exact time at which the data in the packet should be played
- Playback
  - Internet introduces burstiness
  - **Jitter buffer** used to smooth bursts
  - Protocol support needed

Illustration Of Jitter Buffer



- Data arrives in bursts
- Receiver *delays* playback until certain threshold, *k* – playback point
  - *k* too small, still have jitter and freeze of info flow
  - *k* too large, extra delay noticeable to users
- Data leaves at steady rate

RTP: characteristics and functionalities

- Independent from the PHY (obvious!!!)
- Scalable
  - Unicast e multicast
- Defines separate logical channels for data and control
  - indeed a "pair" of protocols RTP-RTC$_{ontrol}$P
- Packet reordering at destination
- Delay jitter equalization with buffers (in addition to the playout buffer of the application)
- Sender identification
- Intra-media synchronization
- No predefined Port, but must be even

RTP: header format

Ver.	P	X	CSRC ct	M	payload type	sequence number
Timestamp						
synchronization source identifier (SSRC)						
content source identifiers (CSRC)						
Extension Headers (optional)						
Data						

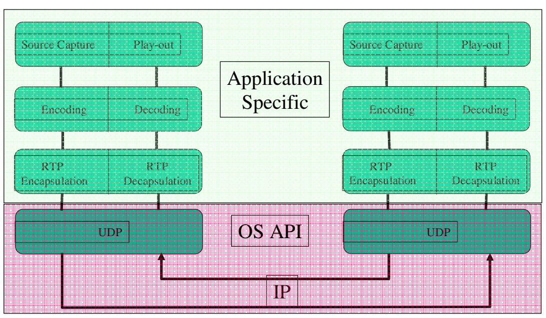
The RTP header (12 bytes)

- Ver.(2 bits): Version of the protocol. Current is 2
- P (1 bit): Indicate if there are extra padding bytes at the end of the RTP packet.
- X (1 bit): Extensions to the protocol used (ELH present)
- CC (4 bits): Number of CSRC identifiers that follow the fixed header
- M (1 bit): If set means that the current data has some special relevance for the application defined in a profile (external to the protocol)
- PT (7 bits): Format of the payload and its interpretation by the application
- SSRC: Indicates the synchronization source and timing
- Extension header: Length of the extension (EHL=extension header length) in 32bit units, excluding the 32bits of the extension header

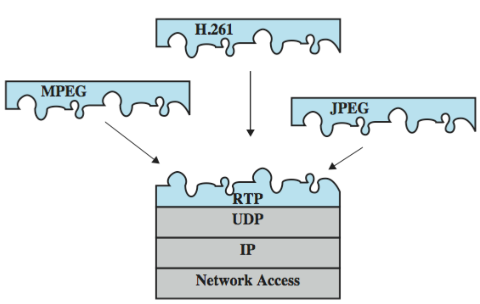
RTCP

- Real Time Control Protocol
- Functionalities:
  - Data Distribution Control
  - Session information advertisement (during the session, not for setup)
  - Distribute information about participants
    - Who is participating in session
    - Who is speaking now
  - QoS feedback
  - Error reporting
  - ...
- RTCP messages are sent on RTP-port+1

RTP Application Programming



Integrated Layer Processing



RTP sending process

- Sending a packet, RTP adds:
  - A timestamp per Application Data Unit (not per packet)
  - A Synchronisation Source Identifier (SSRC)
    - Randomly generated
    - Conflicts resolved
    - **Uniquely identifies flows to receivers**

Why is a flow identifier needed?

Multiple flows may come from the same process (audio and video), the receiver has to separate them (same IP and port)

Translation & Mixing

- Supports changing stream encoding during a session - translation
- RTP can coordinate multiple data streams
- Up to 15 sources (c.f. 4-bit CC field)
- Header specifies mixing
  - Contributing source id – SSRC of streams that were mixed
- Performed through relays, which also provides for multicast

RTP Relays

- relay (or application level routing)
  - operate on intermediary system
  - acts as both destination and source
  - relay data between systems
- mixer
  - combines streams from multiple sources
  - forwards new stream to one or more dests (multicast)
  - may change data format if needed
- translator
  - simpler, sends 1+ RTP packets for each one received

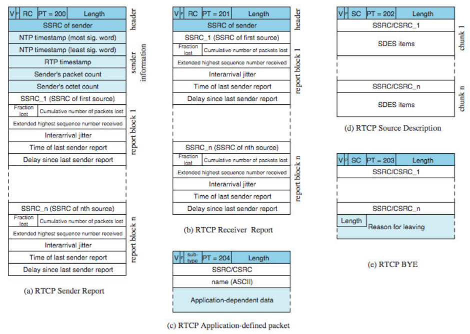
RTP Relays: Further functions

- Mixer
  - New Synchronisation Source Identifier
  - Add old SSRC as Contributing Source Identifiers
- Translator, manipulates the content, e.g. a transcoder

RTCP Packet Types

- have multiple RTCP packets in datagram
- Sender Report (SR)
- Receiver Report (RR)
- Source Description (SDES)
- Goodbye (BYE)
- Application Specific

RCTP Packets



RTCP: generation of reports

- Frequency inv. Proportional to the number of members
  - Excellent scalability (BW limited)
  - Initial "storm"

Report calculations

- Estimate total bandwidth of session
- Sender period T:
- Receiver period T:
- Next packet = last packet + Max(5s, T) + random (0.5-1.5)
- Random prevents synchronization and storms

$$T = \frac{\#Participants}{0.25 \times 0.05 \times SessionBW} \times avg.\_RTCP\_packet\_size$$

RTCP Packets

Receiver report packets:

- fraction of packets lost, last sequence number, average interarrival jitter

Sender report packets:

- SSRC of the RTP stream, the current time, the number of packets sent, and the number of bytes sent

RTCP Bandwidth Scaling

- RTCP attempts to limit its traffic to **5%** of the session bandwidth.

Example

- Suppose one sender, sending video at a rate of 2 Mbps. Then RTCP attempts to limit its traffic to 100 Kbps.
- RTCP gives *75% of this rate to the receivers; remaining 25% to the sender*
- The 75 Kbps is equally shared among receivers:
  - With R receivers, each receiver gets to send RTCP traffic at 75/R Kbps
- Sender gets to send RTCP traffic at 25 Kbps
- Participant determines RTCP packet transmission period by calculating avg RTCP packet size (across the entire session) and dividing by allocated rate