

# SCREAM C++ CODE

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# INTRO

SCReAM (Self-Clocked Rate Adaptation for Multimedia) is a congestion control algorithm devised mainly for Video.

Congestion control for WebRTC media is currently being standardized in the IETF RMCAT WG, the scope of the working group is to define requirements for congestion control and also to standardize a few candidate solutions.

SCReAM is a congestion control candidate solution for WebRTC developed at Ericsson Research and optimized for good performance in wireless access.

The algorithm is submitted to the RMCAT WG [1], a Sigcomm paper [2] and [3] explains the rationale behind the design of the algorithm in more detail. A comparison against GCC (Google Congestion Control) is shown in [4].

Unlike many other congestion control algorithms that are rate based i.e. they estimate the network throughput and adjust the media bitrate accordingly, SCReAM is self-clocked which essentially means that the algorithm does not send in more data into a network than what actually exits the network.

To achieve this, SCReAM implements a feedback protocol over RTCP that acknowledges received RTP packets. The C++ code does not assume that feedback is transmitted over RTCP, on the contrary it is possible to transmit the feedback in RTP header extensions in cases where this alternative is more beneficial.

A congestion window is determined from the feedback, this congestion window determines how many RTP packets that can be in flight i.e. transmitted by not yet acknowledged, an RTP queue is maintained at the sender side to temporarily store the RTP packets pending transmission, this RTP queue is mostly empty but can temporarily become larger when the link throughput decreases.

The congestion window is frequently adjusted for minimal e2e delay while still maintaining as high link utilization as possible. The use of self-clocking in SCReAM which is also the main principle in TCP has proven to work particularly well in wireless scenarios where the link throughput may change rapidly. This enables a congestion control which is robust to channel jitter, introduced by e.g. radio resource scheduling while still being able to respond promptly to reduced link throughput.

SCReAM is optimized using a state the art LTE system simulator for optimal performance in deployments where the LTE radio conditions are limiting. In addition, SCReAM is also optimized for good performance in simple bottleneck case such as those given in home gateway deployments. The C++ code is verified to work with simulated bandwidth limitations in the range 20kbps up ~100Mbps. Live LTE tests in the range 1Mbps to 10Mbps have also been conducted.

This presentation describes the C++ implementation of SCReAM. The package is currently implemented as a Visual Studio 2010 solution but should be straightforward to port to other platforms, additional Cmake files makes it possible to compile the code on most platforms

## References

[1] <http://tools.ietf.org/wg/rmcat/draft-ietf-rmcat-scream-cc>

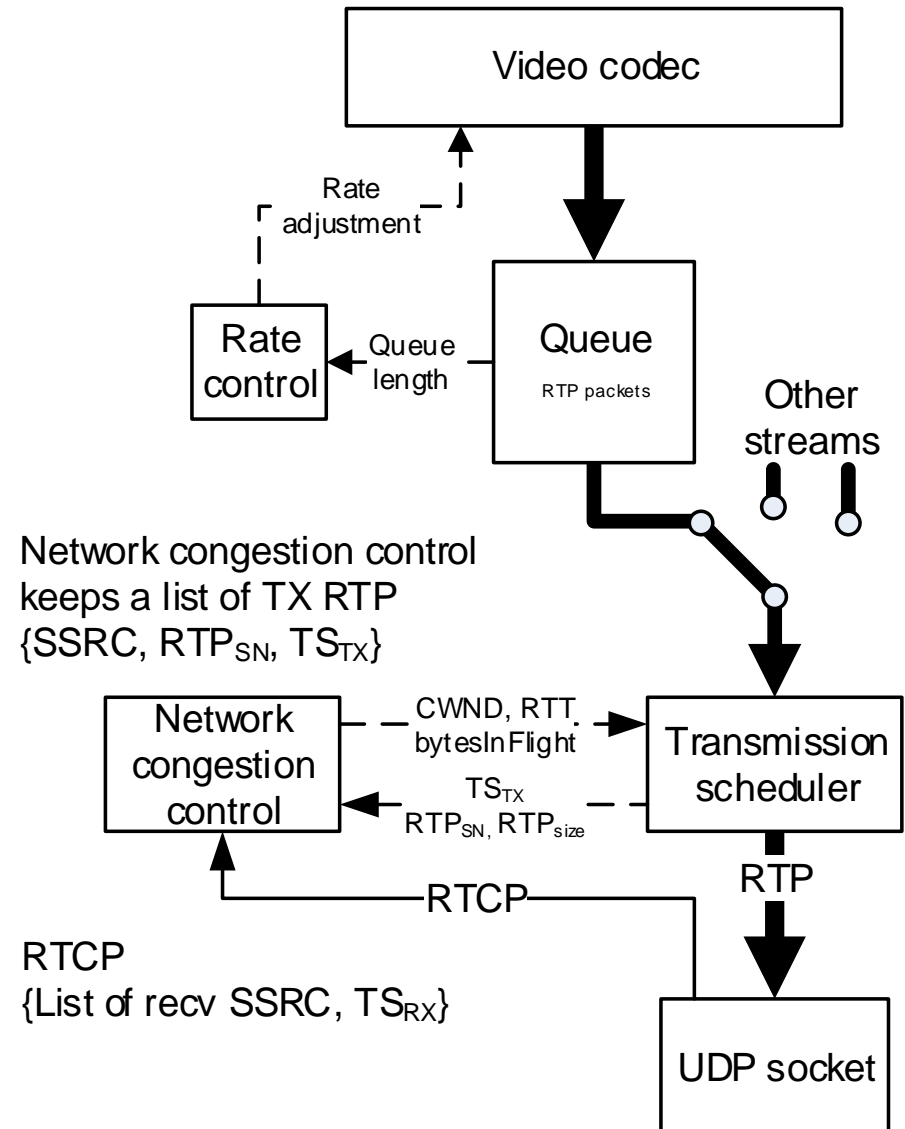
[2] Sigcomm paper <http://dl.acm.org/citation.cfm?id=2631976>

[3] Sigcomm presentation <http://conferences.sigcomm.org/sigcomm/2014/doc/slides/150.pdf>

[4] IETF RMCAT presentation, comparison against Google Congestion Control (GCC) <http://www.ietf.org/proceedings/90/slides/slides-90-rmcat-3.pdf>

# INTRO

- › SCReAM does not allow RTP packets to be transmitted directly
- › Packet transmission is controlled by transmission scheduler which is guided by the network congestion control



# SCReAM CLASSES

## › Main SCReAM algorithm :

- ScreamTx : SCReAM sender algorithm. Does all the intelligent congestion control magic.
- ScreamRx : SCReAM receiver algorithm. Dumber than dumb, just records packet receive times and a list of received packets and prepares feedback elements.

## › Support classes for experiment :

- RtpQueue : Rudimentary RTP queue
- VideoEnc : Simple model of Video encoder
- NetQueue : Simple delay and bandwidth limitation

›

# SCREAMTx

- › Implements SCReAM congestion control algorithm on sender side
- › Contains a reference to class RtpQueue which needs to be replaced if ScreamTx is to be integrated in other platforms
  - RtpQueue replacement need to provide with the following functions
    - › `sizeOfNextRtp()` , size of next RTP packet in RTP queue
    - › `getDelay()` , queuing delay of the oldest RTP packet
    - › `sizeOfQueue()`, aggregate size of all the RTP packets in the queue
    - › `sizeOfLastFrame()`, aggregate size of the RTP packets in the queue with the highest RTP timestamp
- › Time is counted in microseconds (`uint64_t`), microsecond resolution is however not required

# SCREAMTx METHODS

- › `ScreamTx(...)` : Constructor. Allows to set alternative values to `lossBeta`, `queueDelayTargetMin`, `enableSbd` etc.
- › `registerNewStream(...)` : Register a new stream with a given SSRC. A min, max and start bitrate is provided for the rate control. Furthermore a priority indicates priority relative to other streams. In addition it is possible to set alternative values for the `rampUpSpeed`, `maxRtpQueueDelay`, `txQueueSizeFactor`, `queueDelayGuard` etc..

# SCREAMTx METHODS

- › `newMediaFrame(...)` : Called for each new media frame which can generate one or more RTP packets
- › `isOkToTransmit(...)` : Determines if it is OK to transmit an RTP packet for any of the streams. The return values are :
  - 0.0 : OK to transmit one RTP packet from RTP queue indicated by parameter `ssrc`.
  - > 0.0 : Call this function again after a period given by the return value, this implements the packet pacing
  - -1.0 : No RTP packet to transmit or transmission scheduling does not allow for packet transmission

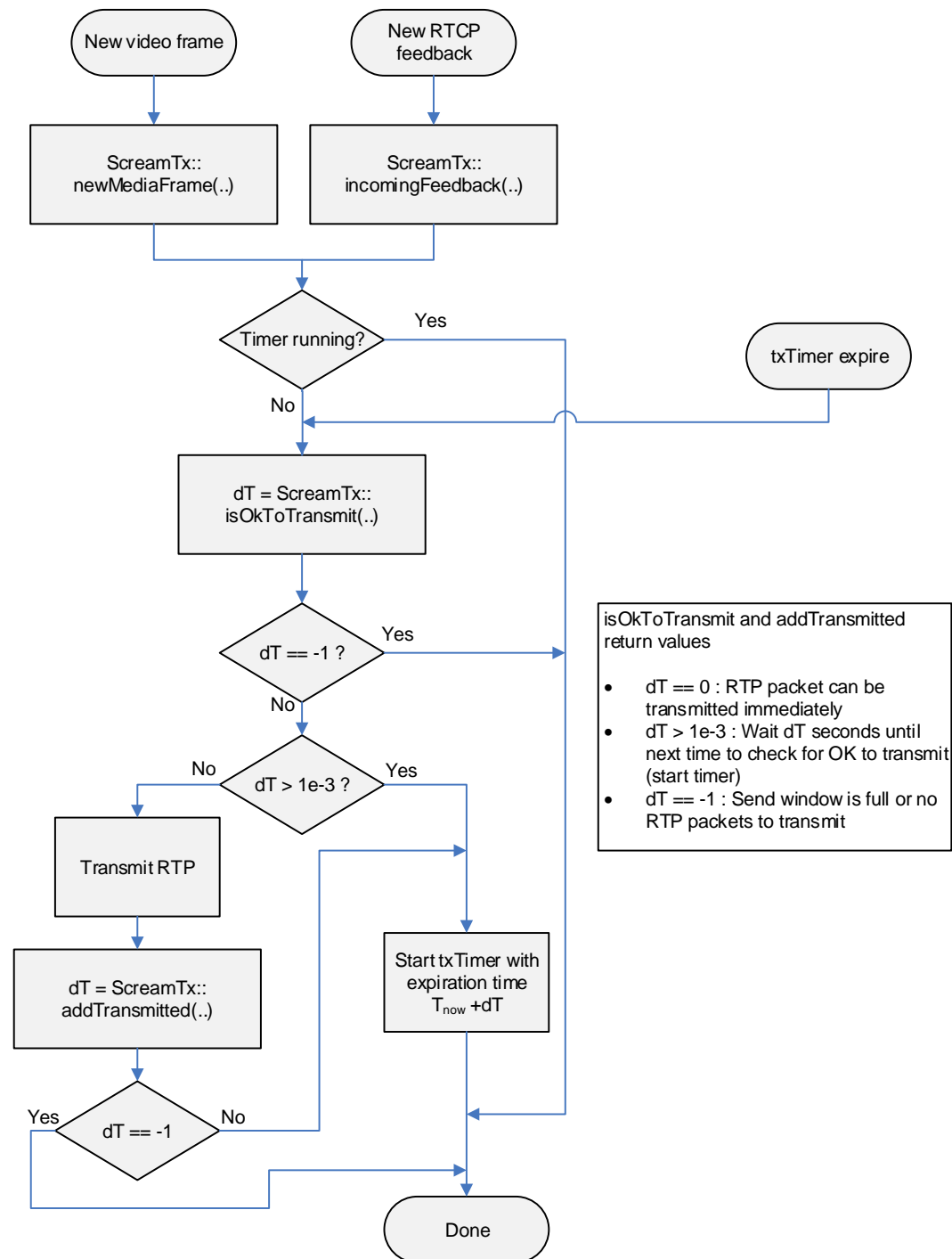
# SCREAMTx METHODS

- › addTransmitted(..) : Called when an RTP packet with SSRC is transmitted, return value indicates when isOkToTransmit(..) can be called again.
- › incomingFeedback(..) : Called for each received SCReAM RTCP feedback message. There are two versions :
  - Parameters seqNr, ackVector, timeStamp are given
  - Unsigned char pointer to RTCP XR packet
- › getTargetBitrate(..) : Get target bitrate for stream identified by parameters ssrc. **NOTE !** This function reports the target bitrate including RTP overhead, the reason is that SCReAM operates in RTP packets. A media encoder must thus subtract the approximate RTP overhead.



# SCREAMTx

› Flowchart describes the SCReAM sender side call flow



# SCREAMRx

- › Implements SCReAM received side functionality and generates RTCP feedback elements
  - Generation of byte correct RTCP packets is not done
  - It is not sure that RTCP is used at all!, RTP header extensions may be more beneficial in some cases.
  - RFC3611 XR blocks for RTCP feedback (see later).

# SCREAMRX METHODS

- › `receive(...)` : Called each time an RTP packet is received, handling of new SSRC i.e. new streams is done automatically.
- › `isFeedback(...)` : Returns true new RTP packets are received and SCReAM RTCP feedback can be transmitted

# SCREAMRX METHODS

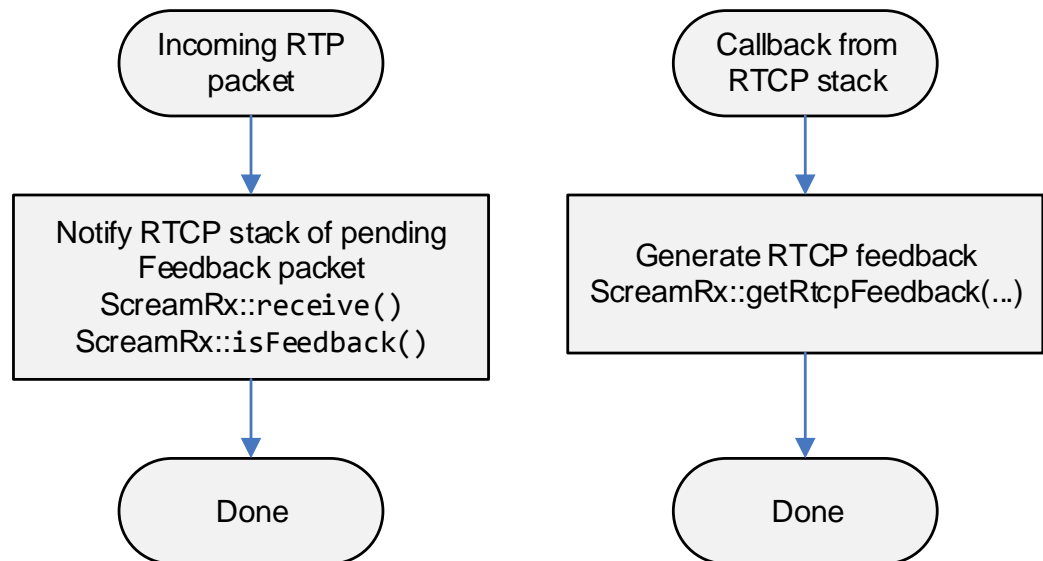
- › `getFeedback(...)` : Get the feedback elements to generate a new SCReAM RTCP feedback packet. Function returns false if no stream with pending feedback available. The feedback elements are:
  - `uint32_t` `ssrc` : SSRC of sender
  - `uint32_t` `receiveTimestamp` : timestamp, default clock frequency = 1000Hz, important that both sender and receiver agree on the same clock frequency
  - `uint16_t` `highestSeqNr` : Highest received sequence number (possibly wrapped around)
  - `uint64_t` `ackVector` : 64 bit ACK vector that indicates reception of RTP packets prior to `highestSeqNr`. The most recent sequence numbers are indicated in the least significant bits, which means that if the ACK vector is truncated, then the LSB should be used.

# SCREAMRX METHODS

- › `createFeedback(...)` : Creates an RTCP XR that is 32 bytes large. Sender and receiver reports may be prepended if needed.

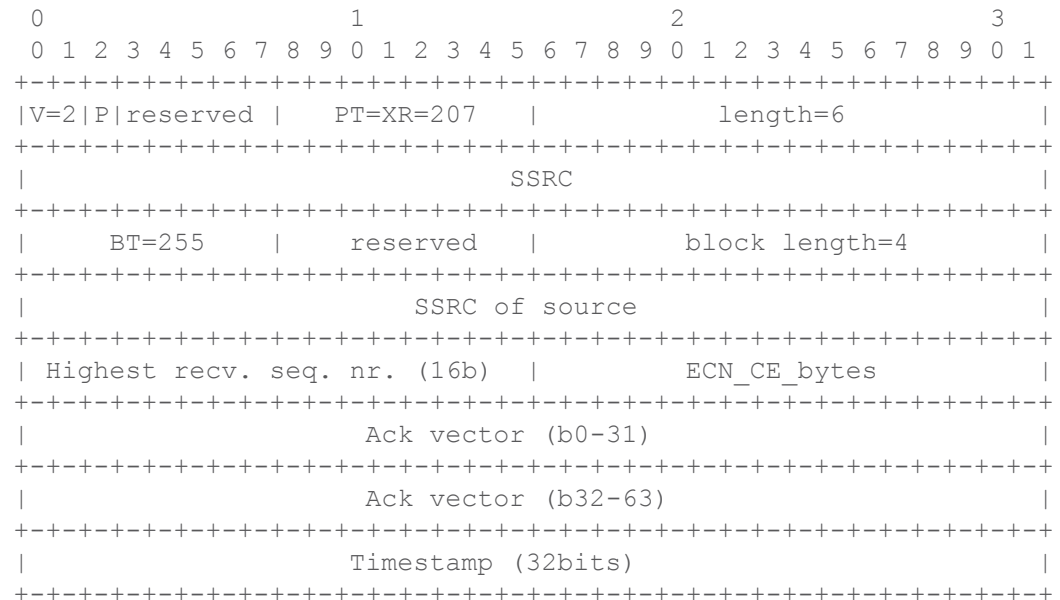
# SCREAMRx

- › Flow chart describes SCReAM received side call flow



# FEEDBACK FORMAT IMPLEMENTED IN C++ CODE

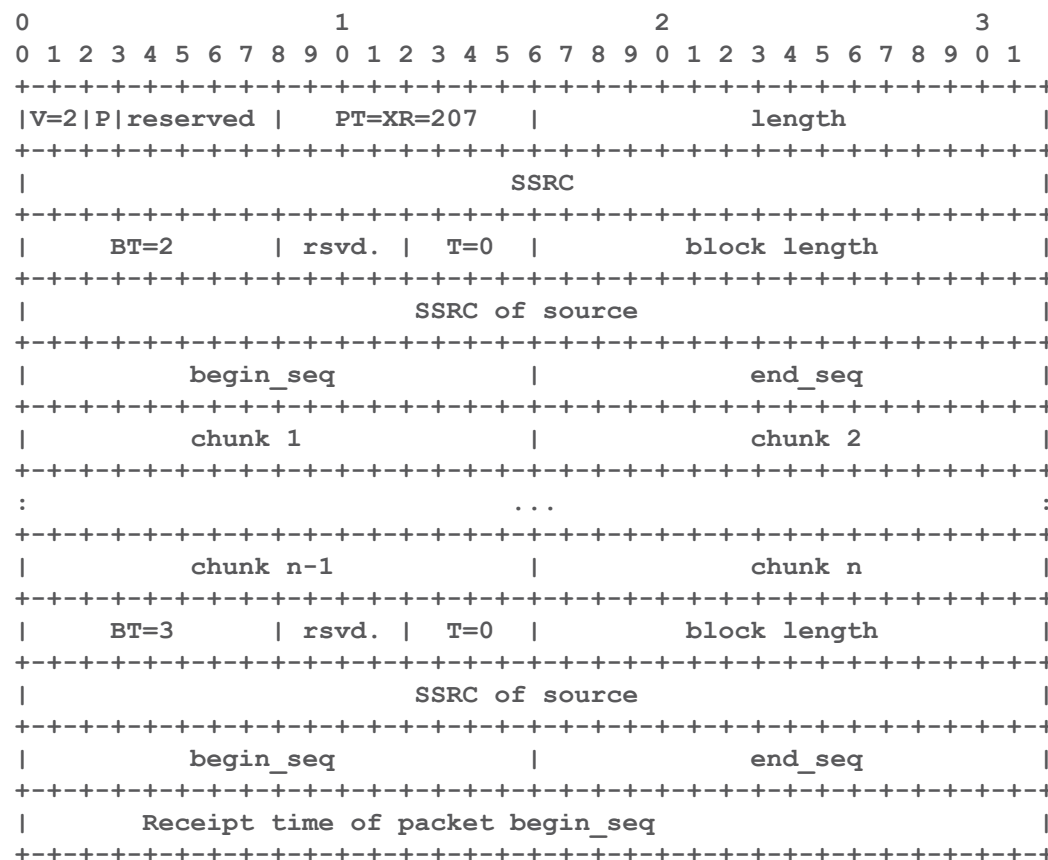
## › Non-standards compliant feedback



# FEEDBACK FORMAT

## RFC3611 REALIZATION

- › The feedback needed for basic functionality is
  - Timestamp
  - List of received SN, highest SN and ACK vector.
- › Basic feedback can be implemented with RFC3611
  - Loss RLE report block
  - Packet Receipt Times block
- › Feedback packet size : 44byte
  - assuming 4 RLE chunks





# FEEDBACK FORMAT

## LOSS RLE REPORT BLOCK, RFC3611

- › Loss RLE report block spans from begin\_seq to end\_seq
- › 4 chunks should be sufficient

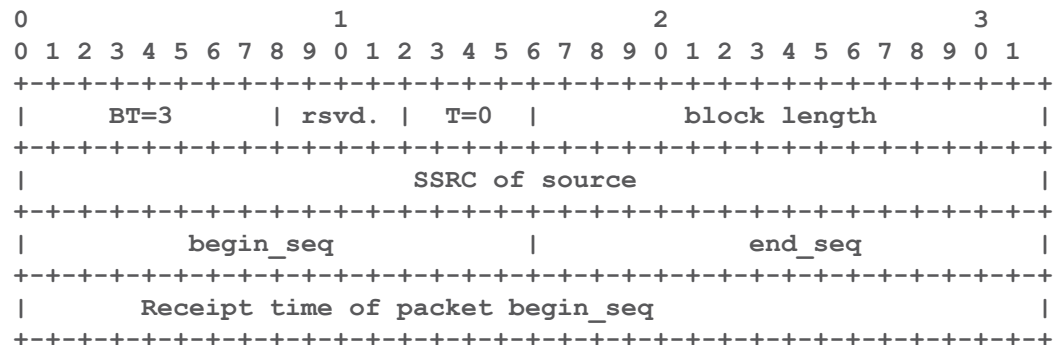
```

0                               1                               2                               3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-----+-----+-----+-----+-----+-----+-----+-----+
|      BT=2      | rsvd. |  T=0  |               block length               |
+-----+-----+-----+-----+-----+-----+-----+-----+
|                                     SSRC of source                                     |
+-----+-----+-----+-----+-----+-----+-----+-----+
|          begin_seq          |          end_seq          |
+-----+-----+-----+-----+-----+-----+-----+-----+
|          chunk 1          |          chunk 2          |
+-----+-----+-----+-----+-----+-----+-----+-----+
:                               ...                               :
+-----+-----+-----+-----+-----+-----+-----+-----+
|          chunk n-1          |          chunk n          |
+-----+-----+-----+-----+-----+-----+-----+-----+
```

# FEEDBACK FORMAT

## PACKET RECEIPT TIMES BLOCK, RFC3611

- ›  $\text{end\_seq} = (\text{begin\_seq} + 1) \% 65536$
- › Receipt time stamp clock according to RFC3611 = Media RTP timestamp
  - It is however possible to use the default 1000Hz clock setting (kTimestampRate in ScreamTx.h)

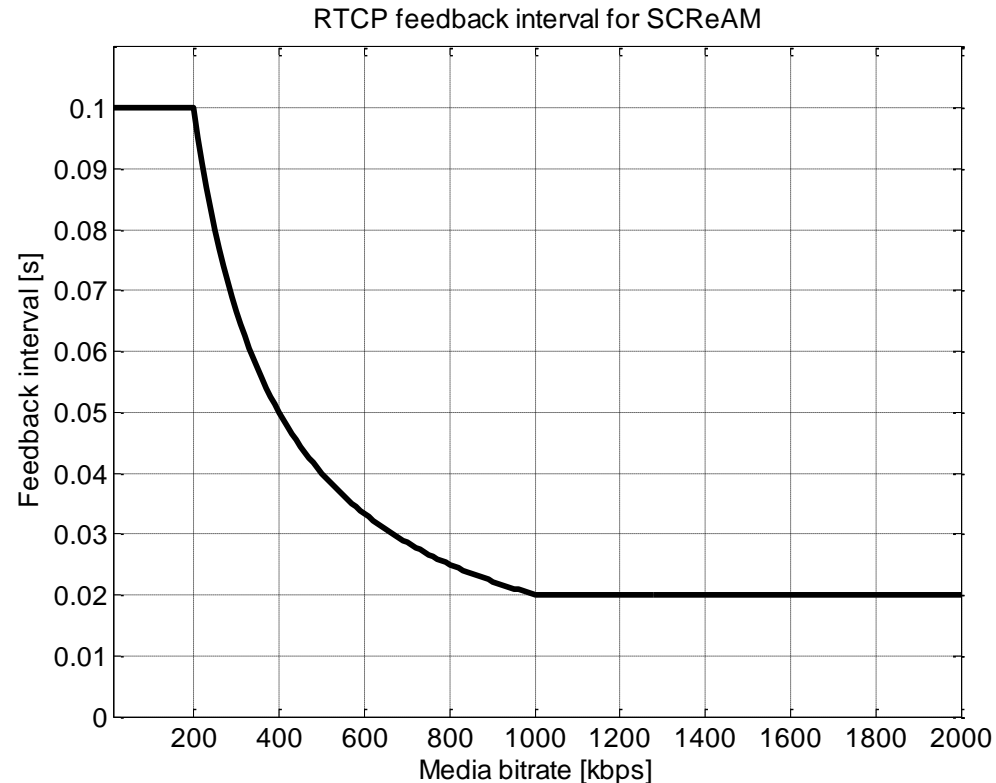


# FALSE LOSS DETECTION

- › Loss RLE block may not cover all received packets since last received feedback
  - Too low feedback rate
  - Feedback is lost
- › Can lead to false loss detection
  - Should be a rare case but cannot be ignored
- › Solution : Regular compound RTCP packets are expected to be transmitted at regular intervals (500ms), interval given by RFC4585 trr-int
  - cumulative number of packets lost : Can be used to undo a false loss detection

# SIGNALING

- › RFC4585 regular mode is sufficient
  - Early mode may be used for application layer signaling (ReTx, FIR..)
- › Reduced size RTCP highly recommended
  - Regular Compound RTCP transmission given by trr-int
- › Signaling rate dependent on bitrate
  - From 100-200ms at low bitrates to 10-20ms at high bitrates
  - Based on empirical data from experiments and simulation
- › C++ implementation: 2% of media rate, limited to feedback interval in the range [1ms,100ms]





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