GStreamer RTP Sessions in Rust

GStreamer Conference 2024

Matthew Waters

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Who Am I?

GStreamer developer and maintainer for over a decade

WebRTC, Vulkan, OpenGL

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RTP: Real-time Transport Protocol

An older relatively simple standard for encapsulating real time data, usually audio/video

RFC 3550: https://datatracker.ietf.org/doc/html/rfc3550

Used in

WebRTC - RTSP - SIP - XMPP - IPTV - RIST - And others

RTP Packet format

```
|    | 0   | 1   | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0  | Version | P | X | CSRC Count    | M | Payload Type                    |
| 2  | Sequence Number                                                        |
| 4  | Timestamp                                                              |
| 6  | Timestamp (continued)                                                  |
| 8  | Sequence Identifier (SSRC)                                             |
| 10 | Sequence Identifier (SSRC) (continued)                                 |
|    | Contribution Source (CSRC) (optional)                                  |
|    | Contribution Source (CSRC) (continued)                                 |
|    | Profile specific Extension header ID (optional)                        |
|    | Extension length                                                       |
|    | Extension data                                                         |
|    | Extension data (continued)                                             |
|    | Payload data                                                           |
|    | Payload data (continued)                                               |
```

P = Padding, X = Extension, M = Marker

RTP Payload formats

Many

- Most Audio and Video Codecs have a defined RTP payload format
- Non audio/video formats are also possible, e.g. KLV, TTML, MIDI, ANC, etc
- Registry: https://www.iana.org/assignments/rtp-parameters/rtp-parameters.xhtml

RTCP: Real Time Control Protocol

Sister protocol to RTP allowing control and feedback messages

- Statistics from both the receiver and sender
  - Who is currently participating in this session?
- Limited to 5% of the session bandwidth
- Integral to Session management

RTCP Packet format

```
|     | 0     | 1     | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0   | Version | P | Count             | Payload Type                    |
| 2   | length                                                            |
```

P = Padding

Prior Art: `rtpbin`

- A `GstBin` that handles most of the intricacies of a RTP session
  - By default includes `rtpjitterbuffer`, SSRC and payload demultiplexing
  - Extension points for Retransmission, FEC, etc

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`rtpbin` - Concerns

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- Number of RTCP threads - one per session
- Inter-stream synchronisation is a multi-element endeavour
- SFU/MCU use cases generally require ‘wormhole’ elements to avoid graph loops

What if we did better?

What if we did better?

And in Rust?

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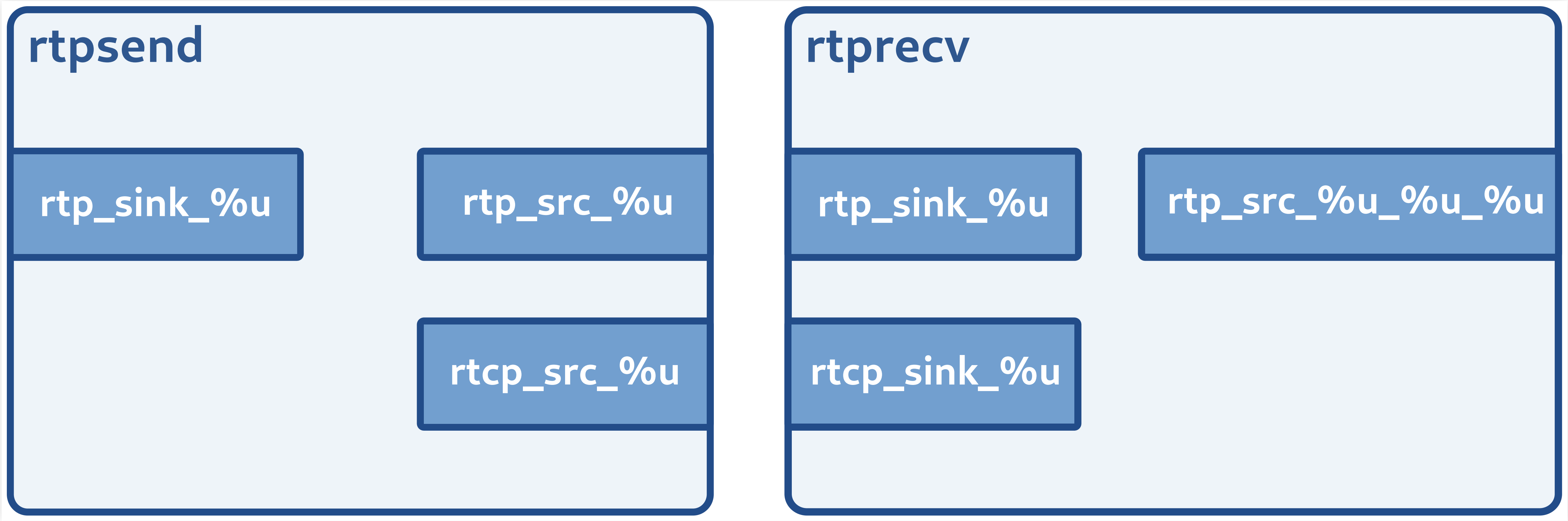
rtpsend + rtprecv



`rtpsend + rtprecv`

Features

- RTP/AVP profile
- RTP/AVPF profile
- PLI/FIR handling
- Reduced size RTCP
- rtcp-mux
- Jitterbuffer
- CNAME synchronisation
- Statistics reporting

`rtpsend` + `rtprecv`

- Two elements now
  - Removes the wormhole requirement for SFU/MCU use cases
- `rtpsend` and `rtprecv` are connected by using the same process unique `rtp-id` value

`rtpsend` + `rtprecv`

Reduced number of RTCP threads

- Uses a tokio runtime internally for RTCP timeouts for all `rtpsend` elements
- Actual RTCP pad push occurs from a tokio blocking thread pool

`rtpsend` + `rtprecv`

Internally sans-IO

- The session handling only operates on the inputs it receives
  - Even including retrieving current time
- Allows for intricate and precise unit testing
- Also reusability
- https://sans-io.readthedocs.io/

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New crate: `rtp-types`

- Parses and writes RTP packets
- RTP Header parsing in <2-3ns
- Generic and extensible writing
    - Could be used by Rust RTP payloaders to directly write from an incoming `GstBuffer` into an output `GstBuffer`
- Can also edit fixed RTP header fields in place

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New crate: `rtcp-types`

- Handles parsing and writing of RTCP packets
  - Sender Report
  - Receiver Report
  - Bye
  - SDES
  - App
- Other RTCP packet types are possible

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Uses

- Optionally used by `rtspsrc2` with `USE_RTP2=1`
- Can already be used by simple RTP scenarios, i.e. most `gst-launch-1.0` pipelines

Demo

Demo

```
rtpsend name=rtp \
src ! vp8enc ! rtpvp8pay ! rtp.rtp_sink_0 \
rtp.rtp_src_0 ! udpsink host=127.0.0.1
```

Demo

```
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```

```
rtprecv name=rtp \
udpsrc caps=... ! rtp.rtp_sink_0 \
rtp. ! rtpvp8depay ! vp8dec ! autovideosink
```

Future

- Retransmissions - main requirement for WebRTC usage
- Forward Error Correction - secondary requirement for WebRTC usage
- RTCP XR
- TWCC: Transport Wide Congestion Control
- Other RTP scenarios

Thanks

Try it out!

- @ystreet00:matrix.org on Matrix
- https://discourse.gstreamer.org/u/ystreet00
- https://gitlab.freedesktop.org/ystreet
- ystreet00@floss.social on mastodon