Audio/Video Bridging (AVB) Support in GStreamer

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Agenda

AVB/TSN Overview

Linux TSN Building Blocks

GStreamer AVTP Plugin

AVB Pipeline Examples

Final Considerations

AVB/TSN Overview

What is Audio/Video Bridging?

Task Group from IEEE 802 (Local Area Networks)

Support time sensitive audio/video applications on LAN

- Sub-microsecond time synchronization
- Bounded transmission latency
- Resource Management
- Interoperability

Market targets

- Pro-AV
- Automotive infotainment
- Consumer electronics

Time Synchronization

IEEE 802.1AS: Generalized Precision Time Protocol (gPTP)

Profile of PTP (IEEE 1588)

Grandmaster clock is elected

All other nodes synchronize with the grandmaster

Bounded Transmission Latency

IEEE 802.1Q: Forwarding and Queueing Enhancements for Time-Sensitive Streams (FQTSS)

- Stream Reservation (SR) Classes: A and B
- SR traffic has precedence over non-SR traffic (e.g. Best Effort)
- Credit-Based Shaper (CBS)

Worst-case latency for 7 hops, 100 Mb/s, Ethernet

- SR Class A: 2 ms
- SR Class B: 50 ms

Resource Management

IEEE 802.1Q: Stream Reservation Protocol (SRP)

End-station A advertises a stream

End-station B attaches to that stream

Bridges in the path between A and B end-station reserve network resources to guarantee the stream transmission across the network

Interoperability

IEEE 1722: Audio/Video Transport Protocol (AVTP)

- Transport protocol for AVB applications
- Carried directly by the Link Layer (L2)

Base protocol

- Stream ID
- Presentation Time (PT)

AVB System Overview

Talker/Listener Roles

Time synchronization via gPTP

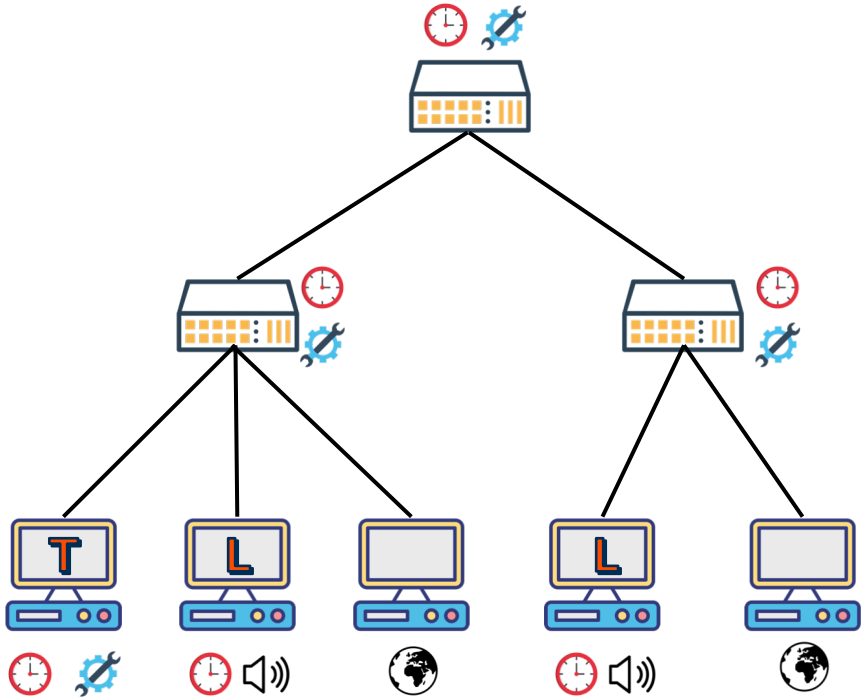
Stream reservation via SRP

- VLAN established
- FQTSS configured

Stream transmission via AVTP

- Playback synchronized via PT

Best effort doesn't disturb the AVB traffic



Time Sensitive Networking (TSN)

AVB technologies are also useful to non-AV use-cases e.g.:

- Industrial
- Automotive

AVB TG renamed to TSN TG

New technologies developed and under development

- Enhancements for Scheduled Traffic (former IEEE 802.1Qbv)
- Frame Preemption (former IEEE 802.1Qbu)
- SRP Enhancements and Performance Improvements (former IEEE 802.1Qcc)

Avnu Alliance

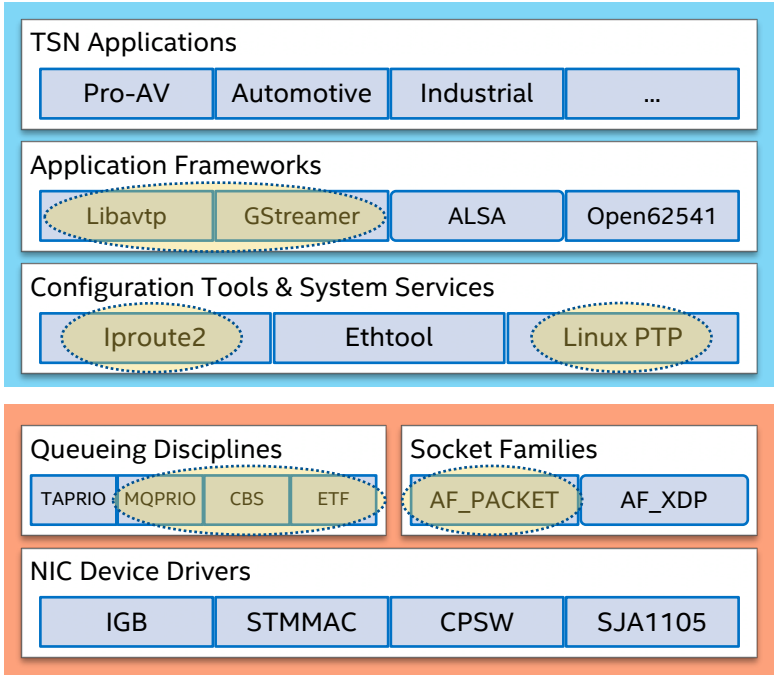
Linux TSN Building Blocks

Linux TSN Building Blocks

Some TSN features are implemented in hardware and others in software

Several TSN features are already supported in upstream Linux Ecosystem

Some blocks are relevant for Gstreamer AVB use-cases



Queueing Disciplines (qdiscs) and Iproute2

MQPRIO qdisc

- Steer traffic to hardware queue based on SKB priority

CBS qdisc

- CBS algorithm implementation
- Support hardware offload

ETF qdisc

- Schedule packet transmission based on SKB timestamp
- Support hardware offload

The *tc* tool from Iproute2 can be utilized to configure the qdiscs

AF_PACKET Socket Family

Send/receive frames from Layer 2

Socket options

- SO_PRIORITY sets SKB priority
- SO_TXTIME enables transmission scheduling
- PACKET_ADD_MEMBERSHIP adds multicast address

bind() allows to filter frames by AVTP EtherType

Linux PTP

Open source implementation of PTP

Support several profiles, including gPTP

ptp4l synchronizes the PTP Hardware Clock (PHC) to the grandmaster clock

phc2sys synchronizes the system clock to the PHC

Libavtp

Open source implementation of AVTP

Helper library to handle AVTP packetizaton

Format support

- AVTP Audio Format (AAF)
- Compressed Video Format (CVF)
- IEC 61883/IIDC Format
- Clock Reference Format (CRF)

Gstreamer AVTP Plugin

AVTP Plugin

Provide elements to implement AVB talker and listener applications

Currently supported formats

- AAF (PCM encapsulation)
- CVF (H.264 encapsulation)

Plugin is part of gst-plugins-bad module

Unit tests for all elements (~80% of lines of code coverage)

Documentation available

Plugin will be available in next stable release (1.18)

LGPL license

Payload Elements

One payload element for each AVTP format

Input media data, output AVTP frames

Calculate AVTP Presentation Time based on GstBuffer timestamps

Common properties

- Stream ID
- Maximum Transit Time (MTT)
- Time Uncertainty (TU)

Depayload Elements

One depayload element for each AVTP format

Input AVTP frames, output different types of media

Set GstBuffer timestamps based on AVTP Presentation Time

Common properties

- Stream ID

Avtpsink Element

Handle AVTP frames transmission

Extend GstBaseSink class

Properties

- Address: Stream destination MAC address
- Ifname: Network interface name where AVTPDUs are sent
- Priority: socket priority (SO_PRIORITY)

Avtpsrc Element

Handle AVTP frames reception

Extend GstPushSrc class

Properties

- Address: Stream destination MAC address
- Ifname: Network interface name where AVTP frames are received

AVB Pipeline Examples

Preamble

The plugin assumes:

- PHC is synchronized with gPTP grandmaster clock
- System clock is synchronized with PHC
- Pipeline is clocked by GstSystemClock (GST_CLOCK_TYPE_REALTIME)
- Network resources have been reserved

Instructions on how to achieve that are provided in AVTP Plugin documentation

AVB Pipeline Examples

AVB Stream: SR Class B, AVTP Audio Format, PCM 16-bit sample, 48 kHz, stereo, 12 audio frames per AVTP frame

```
audiotestsrc samplesperbuffer=12 ! audio/x-
raw,format=S16BE,channels=2,rate=48000 ! avtpaafpay
mtt=50000000 tu=1000000 streamid=0xAABBCCDDEEFF000B !
avtpsink ifname=eth0.5 address=01:AA:AA:AA:AA:AA
priority=2
```

```
avtpsrc ifname=eth0.5 address=01:AA:AA:AA:AA:AA !
avtpaafdepay streamid=0xAABBCCDDEEFF000B !
autoaudiosink
```

Final Considerations

Work In-Flight

Avtpsink's own synchronization mechanism

- Avtpsink uses GstBaseSink rendering synchronization mechanism
- SR Class A streams demands transmission at every 125 us
- Leverage socket transmission scheduling feature introduced in 4.19
- Improves transmission time accuracy considerable

	Mean	Stdev	Min	Max	Range
Before	125000	2401	110056	288432	178376
After	125000	18	124943	125055	112

Work In-Flight (continued)

Clock Reference Format (CRF) support

- Provides a reference media clock
- Talkers adjust the Presentation Time so it is phase-locked with the reference clock provided by CRF stream
- Listeners check if incoming streams are synchronized with reference clock

Merge Requests have been posted on Gitlab, please help reviewing them!

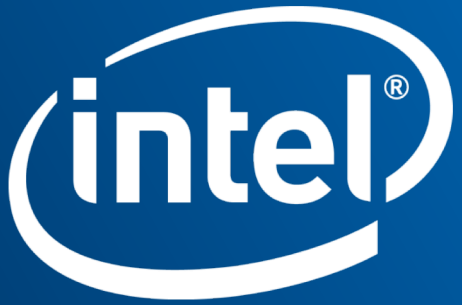
Future

Implement MPEG-TS encapsulation (AVTP IEC 61883/IIDC Format)

Filter AVTP frames by StreamID in avtpsrc

Promote the AVTP plugin to gst-plugins-good module

Questions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