GstShark profiling: a real-life example

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Introduction

- Michael Grüner
  - Technical Lead at RidgeRun
  - Digital signal processing and GStreamer to solve challenges involving Audio, Video and embedded systems
- David Soto
  - Engineering Manager at RidgeRun
  - Lead team to find GStreamer solutions
  - Convert customers ideas to create real products

RidgeRun - where do we work?

- +12 years developing products based on Embedded Linux and GStreamer - 100% require multimedia
- Embedded systems and limited resources - optimal solutions
- Looking for powerful embedded platforms with coprocessors (GPUs, DSPs and FPGAs) + GStreamer
- Provides Infrastructure

Location

US Company - R&D Lab in Costa Rica

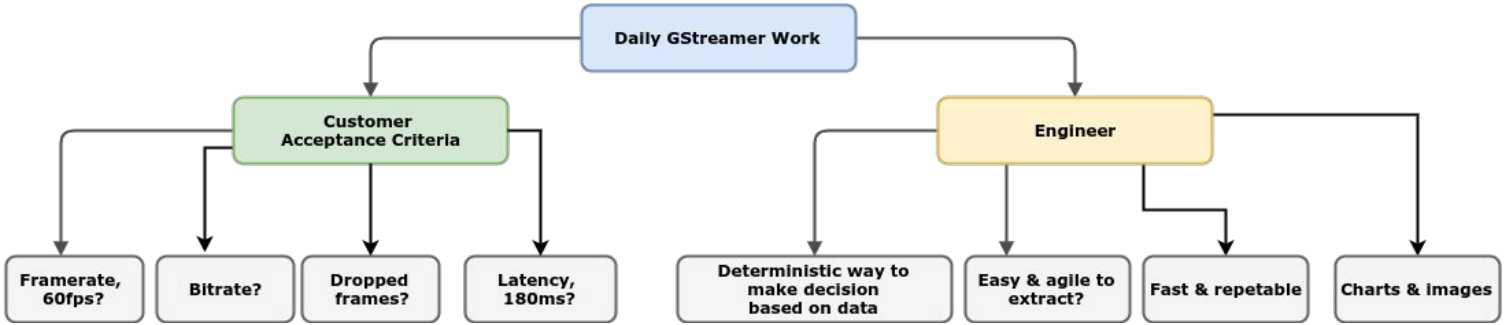
Overview

- The need behind the tool
- Problem to solve
- Solution: GstShark
- GstShark - A Real Life Example
- Future work
- Code
- Questions

Motivation (1)

- No standard way to tune GStreamer pipeline - iterative but without tools to obtain performance data
  - Element to print CPU load - where to place it?
  - Patch elements to add prints - hackish
  - Not maintainable
- GStreamer tracing subsystem now provides the hooks

Motivation (2)



Deterministic data measurement - win-win for both to find bottlenecks

Problem

Is there an easy way to get profiling measurements from the pipeline to identify bottlenecks and to get a more stable and optimized design?

Solution: GstShark

- Take pipeline profiling data and used it on a single, standard tool called GstShark
  - Make better decisions

Demonstrated today on NVIDIA Tegra X1

Tegra X1

- Embedded system created by NVIDIA
- 6x1080p30 MIPI CSI Cameras or single up to 4K@60fps
- Hardware encoders/decoders for H264, H265 and VP8
- Maxwell GPU with 256 cuda cores - RidgeRun using with GStreamer

GstShark - What is it?

- Profiling and benchmarking tool for GStreamer pipelines.
- Front-end for GStreamer's tracing subsystem.

GstShark - GStreamer's tracing subsystem

- API added on release 1.7.1 around 2015 (thanks Stefan)
- Install callbacks on predefined "hooks" - strategic pieces of code, i.e buffer push
- low-level measurements translated to “tracers”
  - Processing time
  - Latency
  - Bitrate, etc
- Run time linked
- Activated by environment variables

GstShark

- Open Source project developed by RidgeRun
- Adds a set of tracers for high level measurements
- Tracers chosen by customers (room for more!)

GstShark - New GStreamer Tracers

- Bitrate
- Framerate
- CPU usage
- Queue level
- Schedule time
- Inter-latency
- Processing time
- Graphic

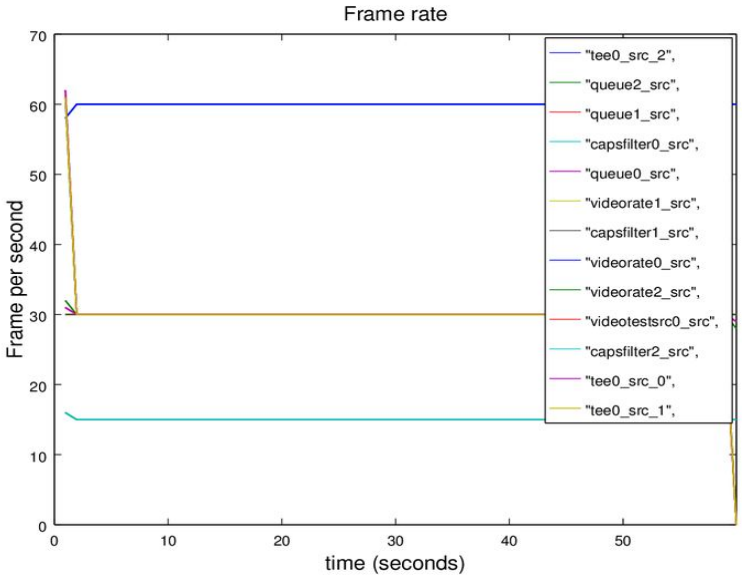
GstShark - Bitrate Tracer

- Bits per second that pass through every pad in the pipeline
- Validate encoders configuration (compression)

Great way to verify adaptive bitrate streaming is working as expected

GstShark - Framerate Tracer

- Frames passing per second through every pad in the pipeline
  - Scheduling issues, bottlenecks and stability problems



Now you have a way to attack jittery video

GstShark - CPU Usage Tracer

- Prints once every second the CPU usage while pipeline is running.
  - Per core - all system load

Identify dropped frames caused by another process hogging the processor

GstShark - Queue Level Tracer

- Amount of data currently held by pipeline queues
  - number of buffers, bytes or even time
  - Should be constant - not increasing (bottleneck)

Latency tuning is finding unnecessary buffer queueing

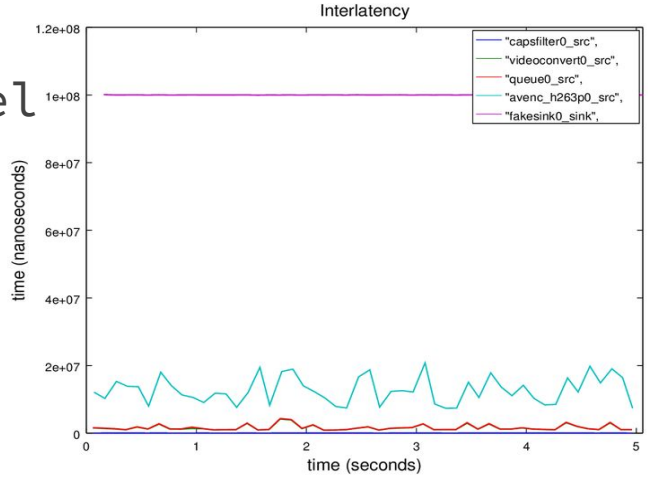
GstShark - Schedule Time Tracer

- Time between two consecutive buffers in a pad
  - 30fps live pipeline, should be 33ms
  - It is different to processing time
  - Think on queues: 33ms schedule time but higher processing time.

Identify buffer drops and pipeline hogs

GstShark - Inter-Latency Tracer

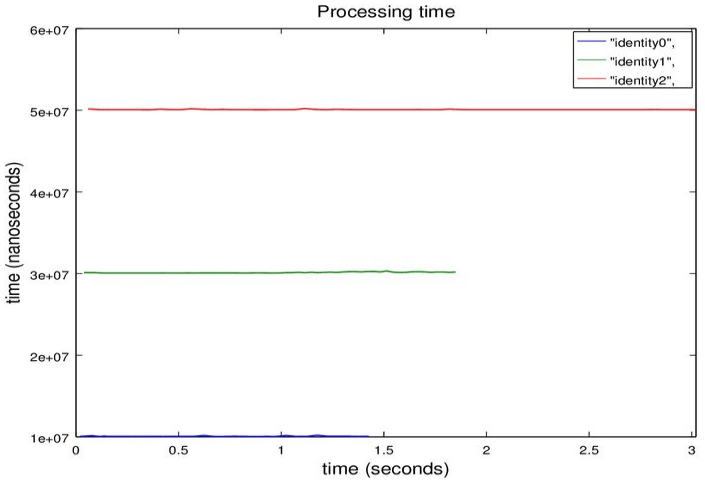
- Time it takes for a buffer to travel from a source element to other elements
  - overall latency: inter-latency from 1st source to last element
- Reports latency in different parts of the pipeline (data buffering)



Great way to measure how each element contributes to pipeline latency

GstShark - Processing Time Tracer

- Time an element takes to process a single buffer
  - Tricky with tee or demux
  - Valid only for single input/output elements



Identify elements needing tuning or hardware acceleration

GstShark - Graphic Tracer

- Pop-up a window with the pipeline graph
  - Shortcut for "dump dot file" utility
  - Opens a window instead of file creation

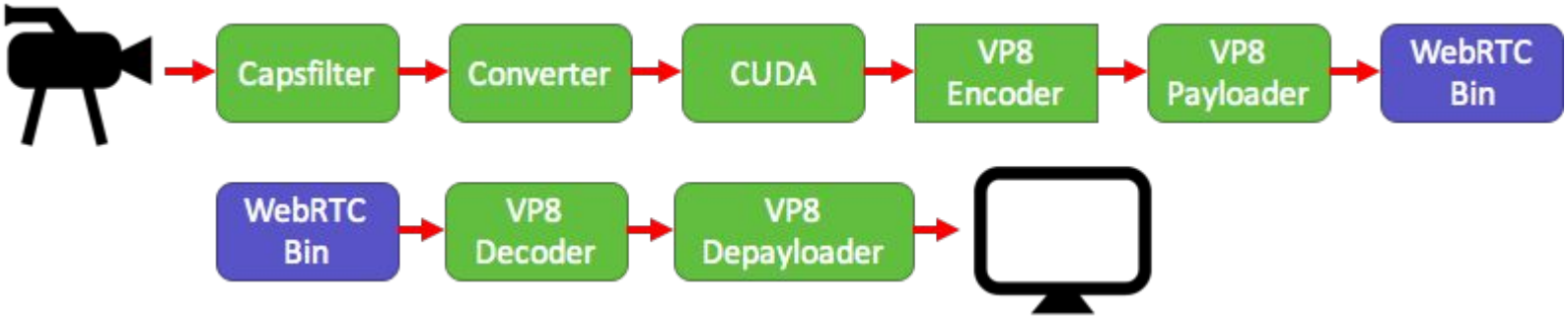
GstShark - Tracer outputs

- GStreamer's debug - most intuitive way
  - Activate desired tracers
  - Enable GST_TRACER debug category - separated by semicolon
- **CTF (Common Trace Format)** file
  - Directory with date and time with the traces of the latest session
  - Can be read by Eclipse or babeltrace for more analysis
- GNU/Octave scripts to plot the data (provided)

GstShark - A Real Life example

- WebRTC Streaming Pipeline
  - VP8 Encoder
  - Full HD (1080P)
  - 30 FPS
  - < 200ms latency

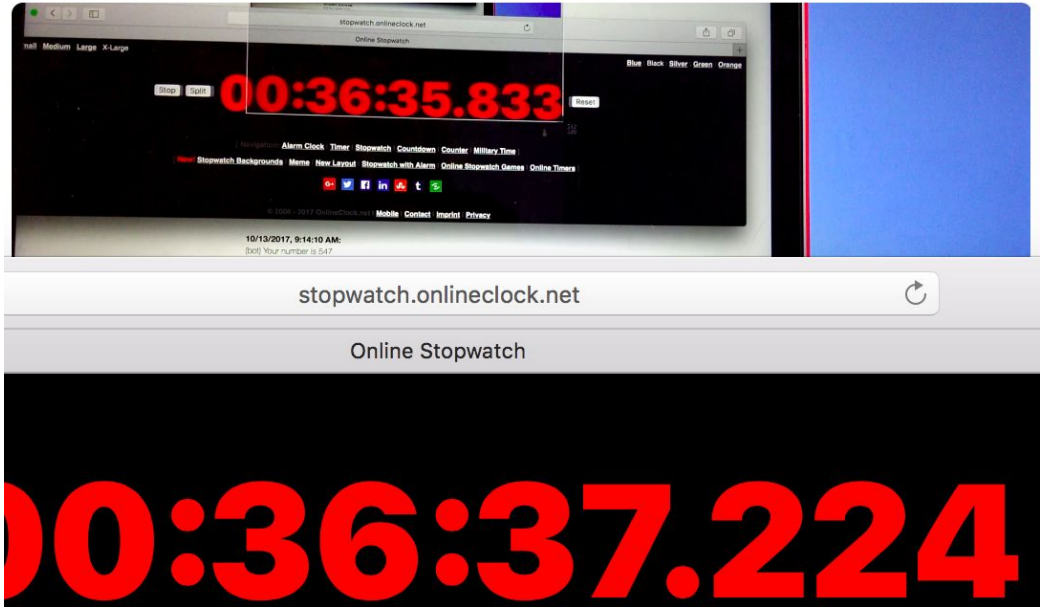
GstShark - Iteration 1



GstShark - Iteration 1

gst-launch-1.0 webrtcbin rtcp-mux=true start-call=false signaler::user-channel=ridgerun name=web nvcamerasrc ! "video/x-raw(memory:NVMM),width=1920,height=1080" ! nvvidconv flip-method=rotate-180 ! cuda ! omxvp8enc ! rtpvp8pay ! web.video_sink web.video_src ! rtpvp8depay ! omxvp8dec ! nvoverlaysink

GstShark - Iteration 1




```
  7.224
- 5.833
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  1.391
```
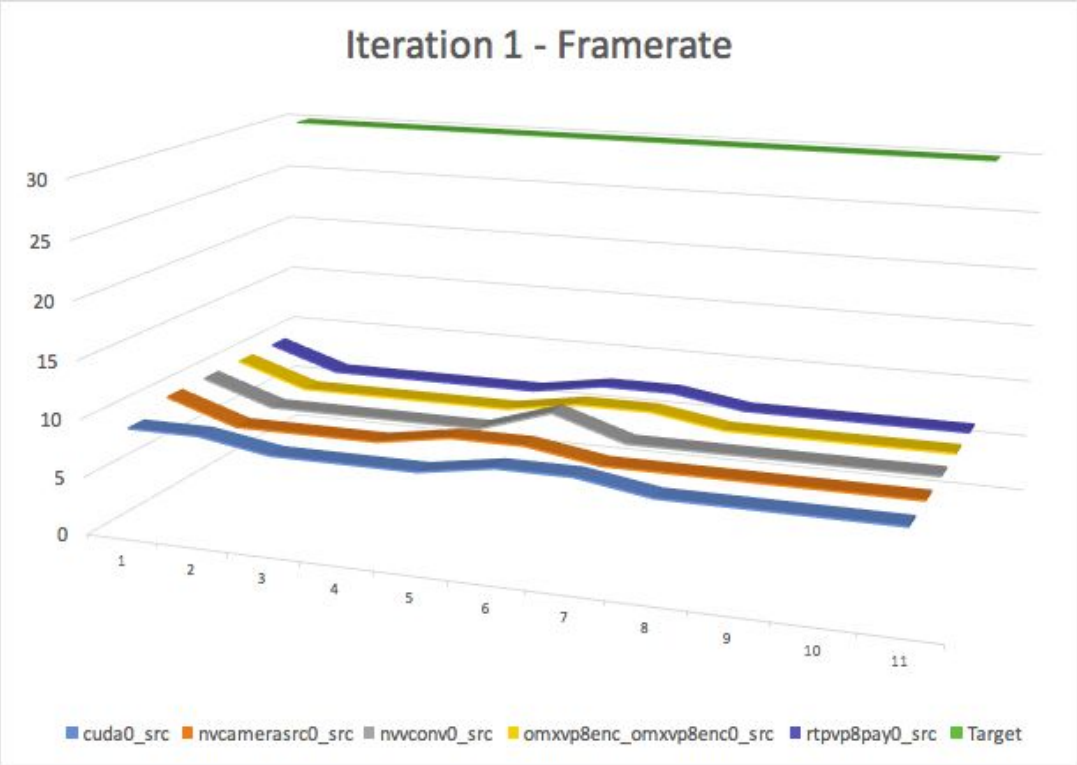

GstShark - Iteration 1

- VP8 Encoder ✓
- Full HD ✓
- 30 FPS ✗
- 200 ms latency ✗

GstShark - Iteration 1



GstShark - Iteration 1

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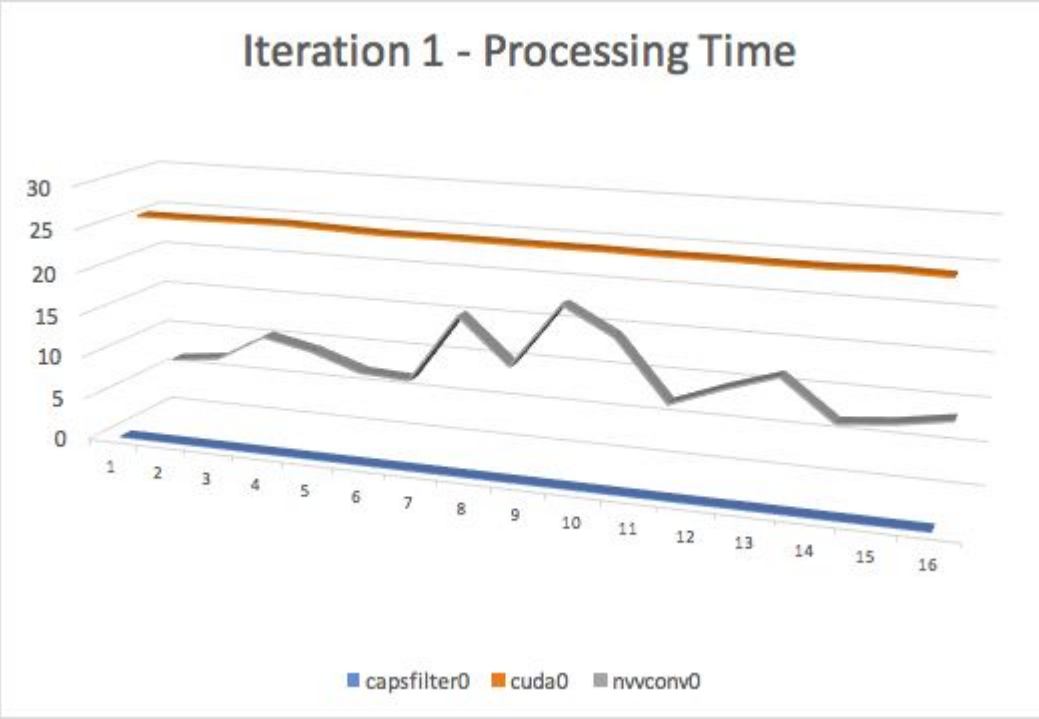
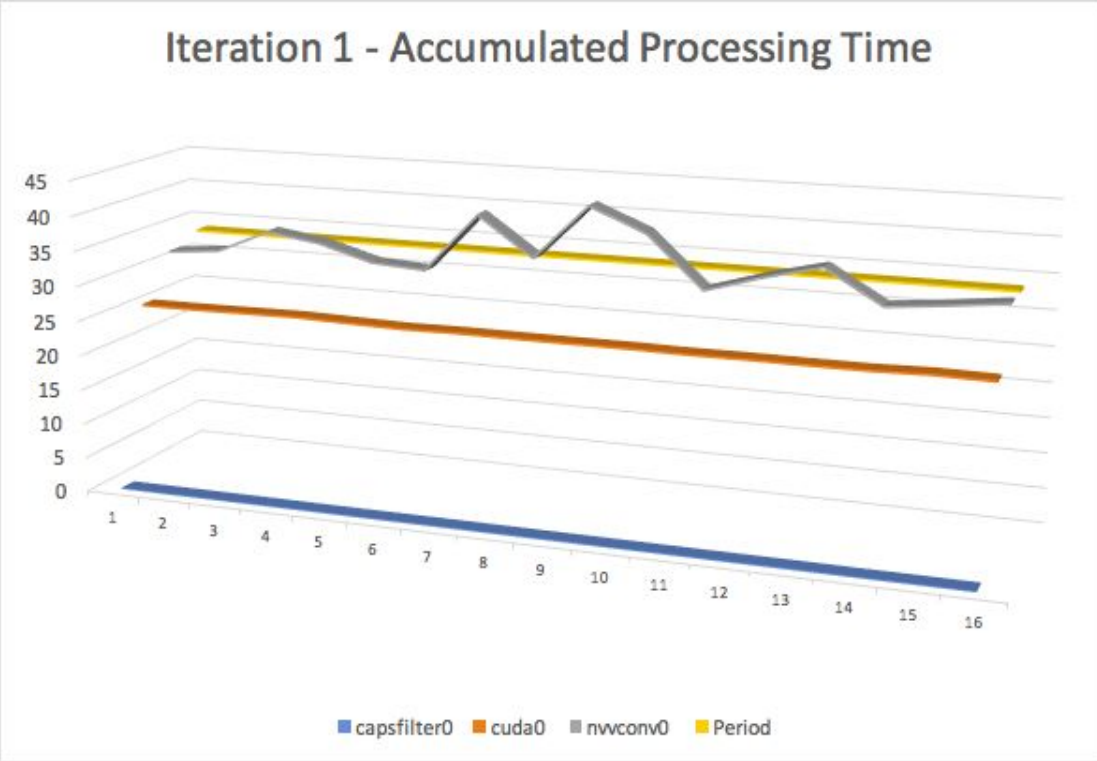
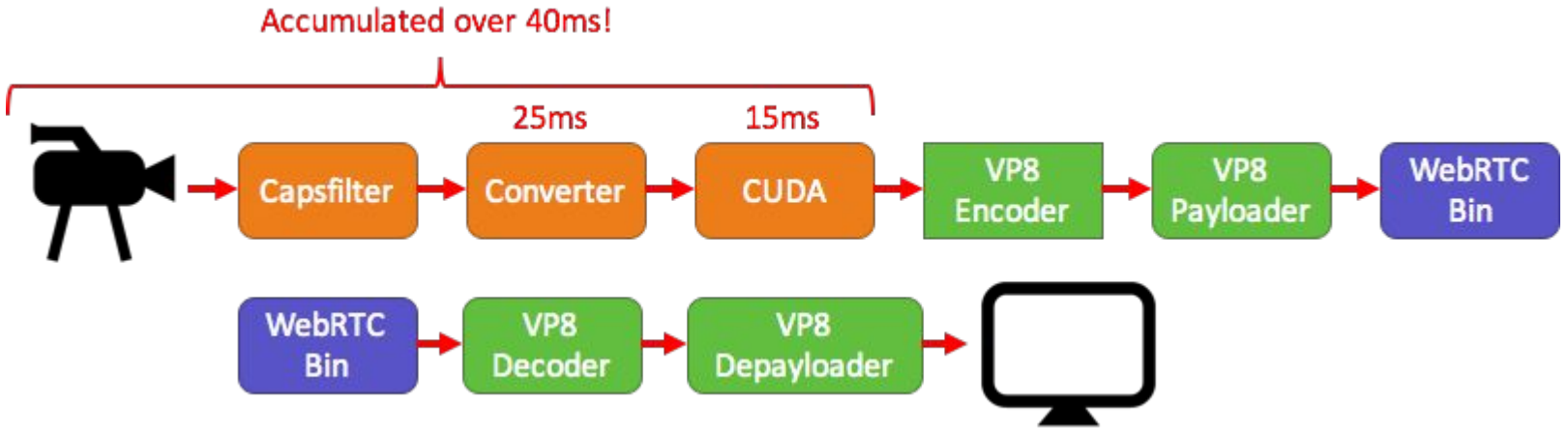


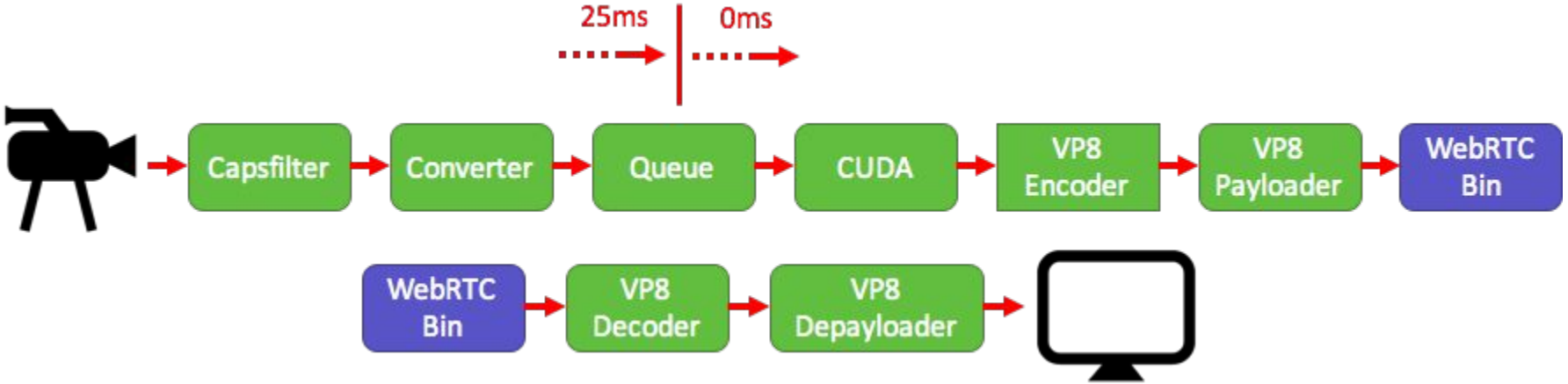
GstShark - Iteration 1



GstShark - Iteration 1



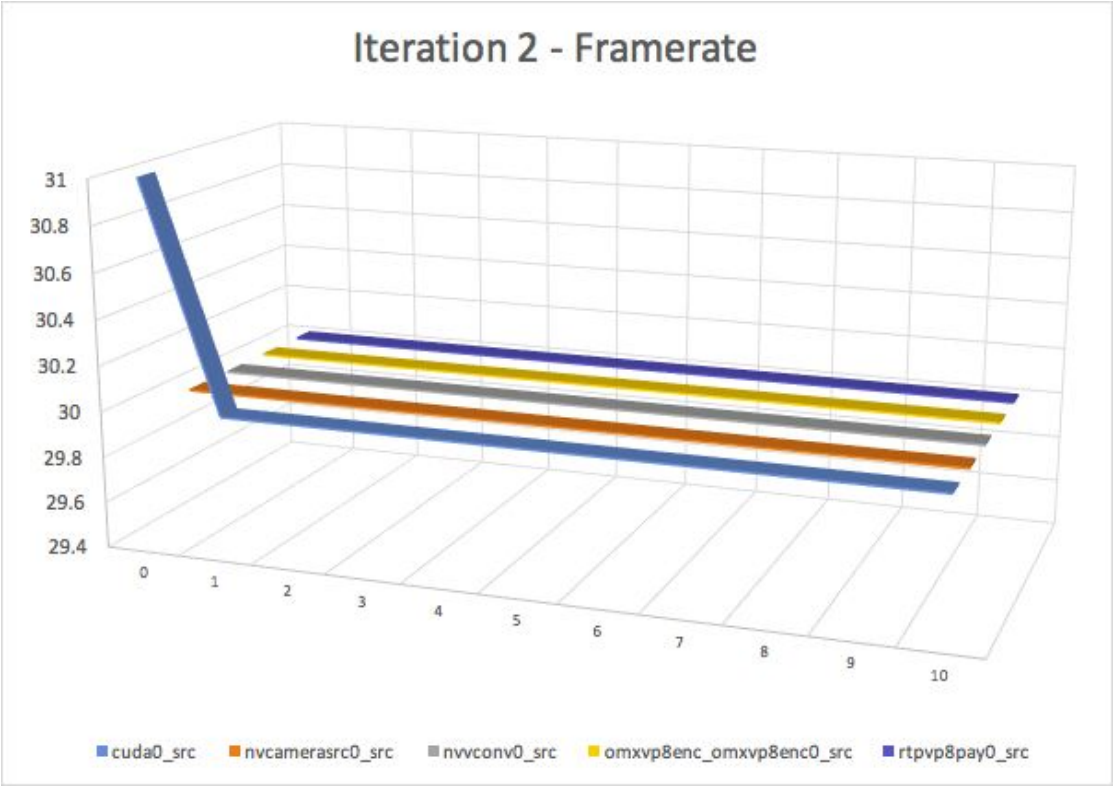
GstShark - Iteration 2



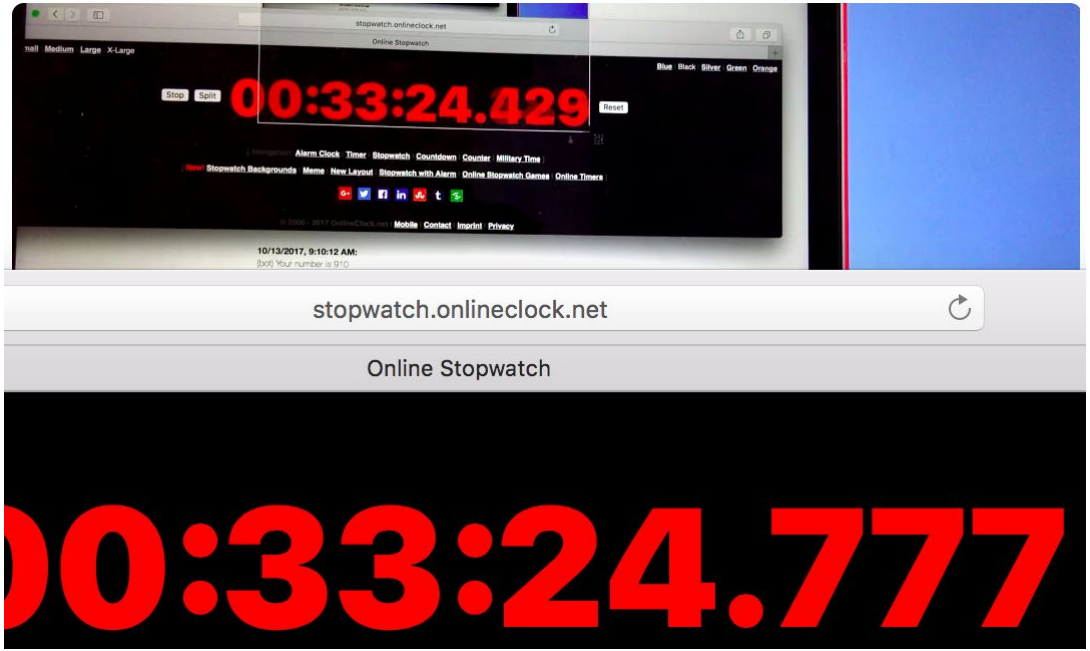
GstShark - Iteration 2

gst-launch-1.0 webrtcbin rtcp-mux=true start-call=false signaler::user-channel=ridgerun name=web nvcamerasrc ! "video/x-raw(memory:NVMM),width=1920,height=1080" ! nvvidconv flip-method=rotate-180 ! queue ! cuda ! omxvp8enc ! rtpvp8pay ! web.video_sink web.video_src ! rtpvp8depay ! omxvp8dec ! nvoverlaysink

GstShark - Iteration 2



GstShark - Iteration 2



4777

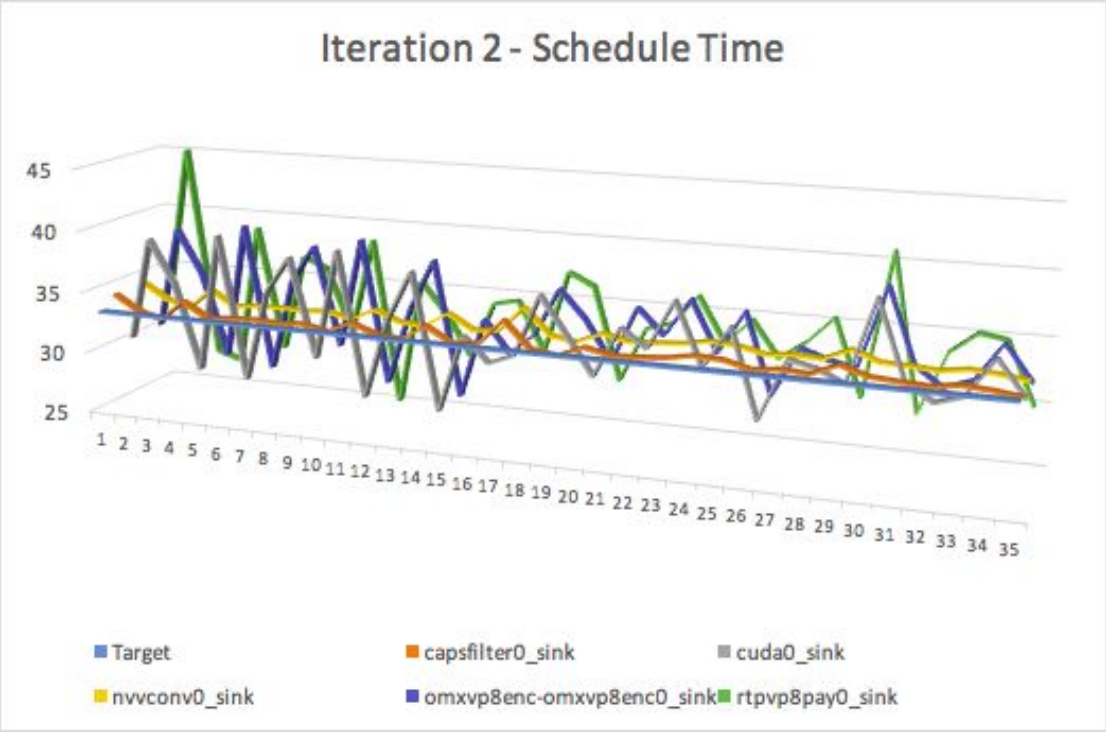
\- 4429

348

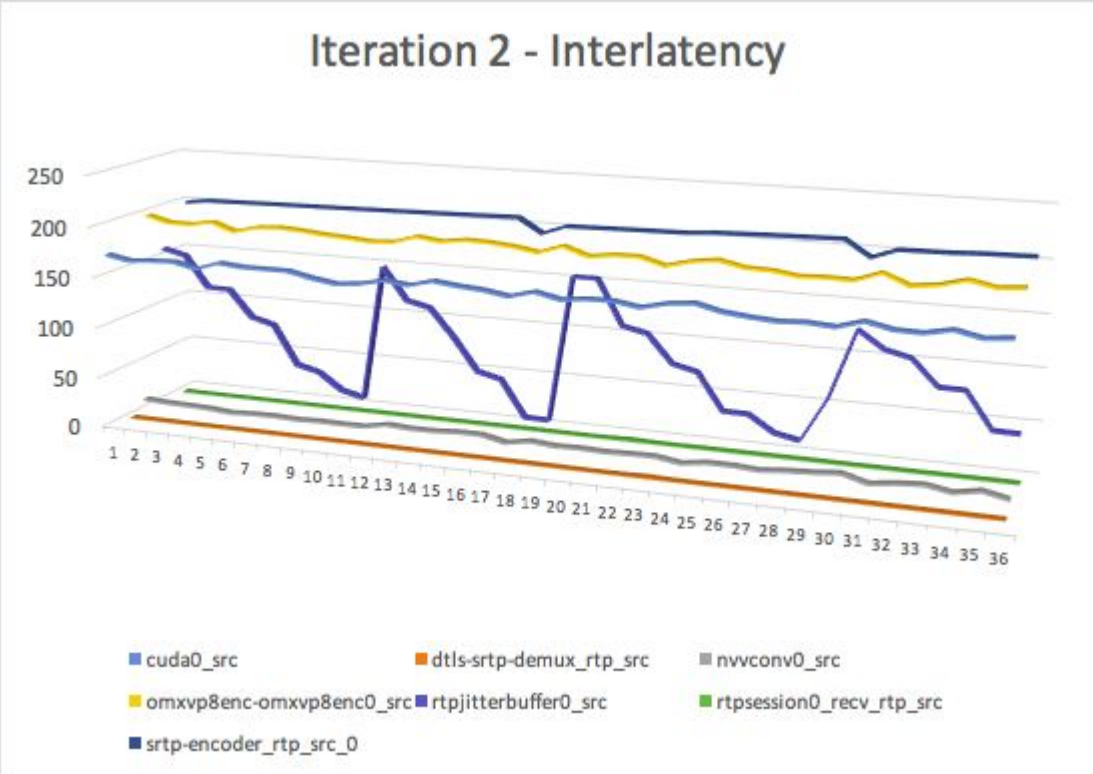
GstShark - Iteration 2

- VP8 Encoder ✓
- Full HD ✓
- 30 FPS ✗
- 200 ms latency ✗

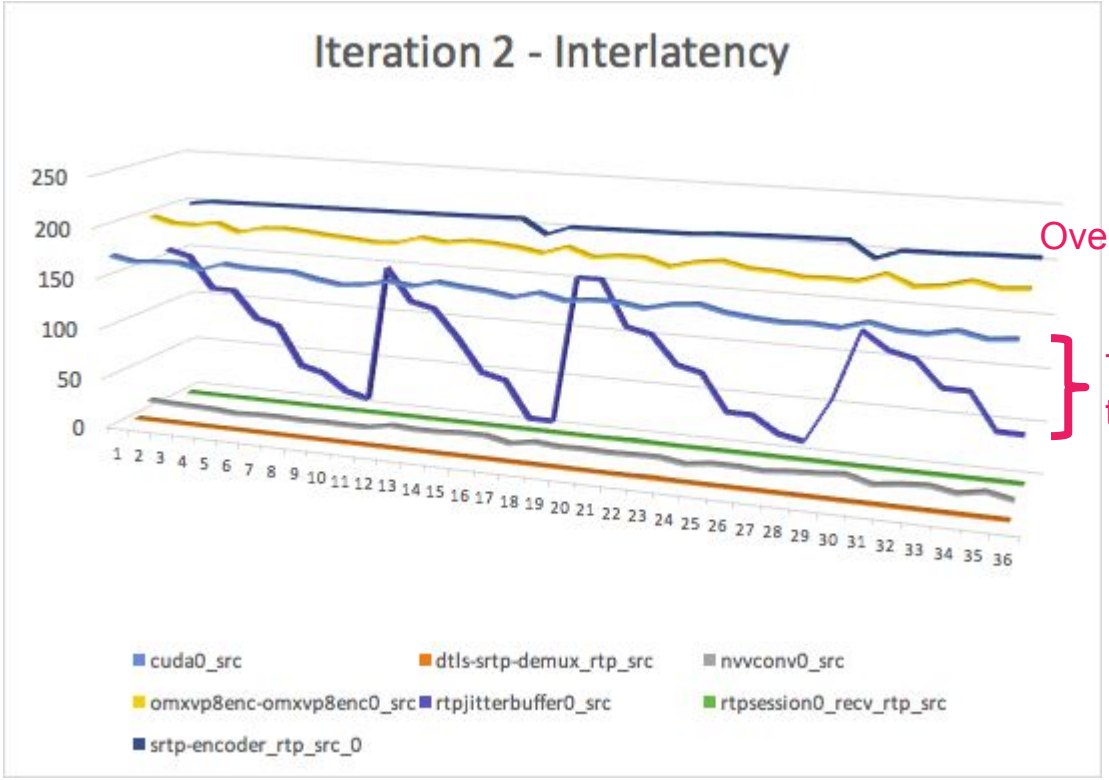
GstShark - Iteration 2



GstShark - Iteration 2



GstShark - Iteration 2



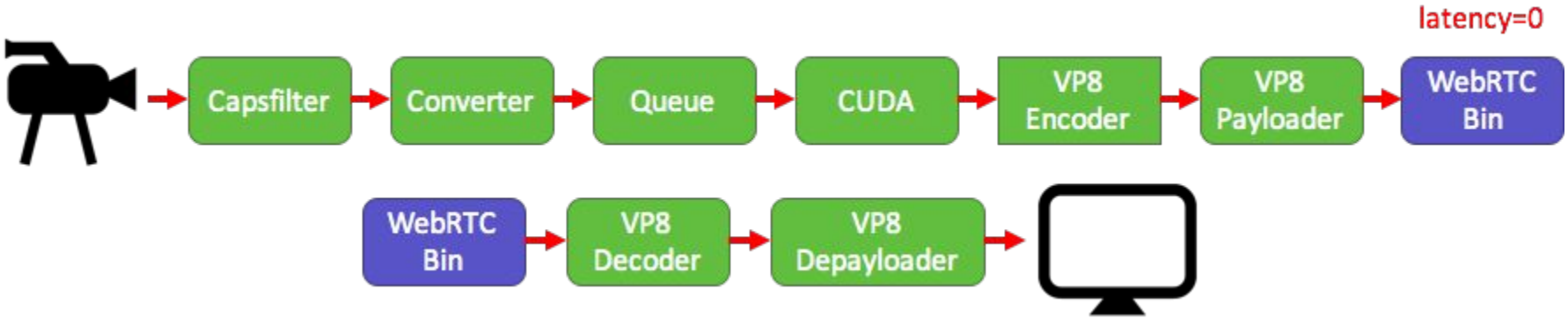
Overall pipe latency

The gap accounts for the element latency

GstShark - Iteration 2

```
---
        gst-inspect-1.0 rtpjitterbuffer
        Factory Details:
          Rank                          none (0)
          Long-name                     RTP packet jitter-buffer
          Klass                         Filter/Network/RTP
                                ...
latency             : Amount of ms to buffer
                      flags: readable, writable
                      Unsigned Integer. Range: 0 - 4294967295 Default: 200
```

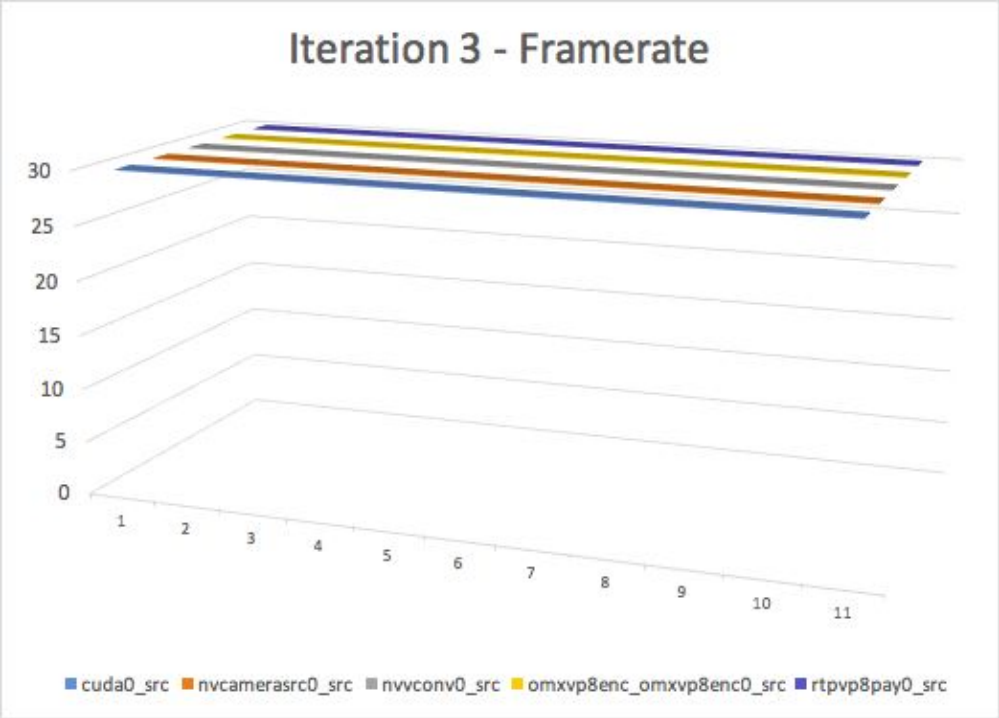
GstShark - Iteration 3



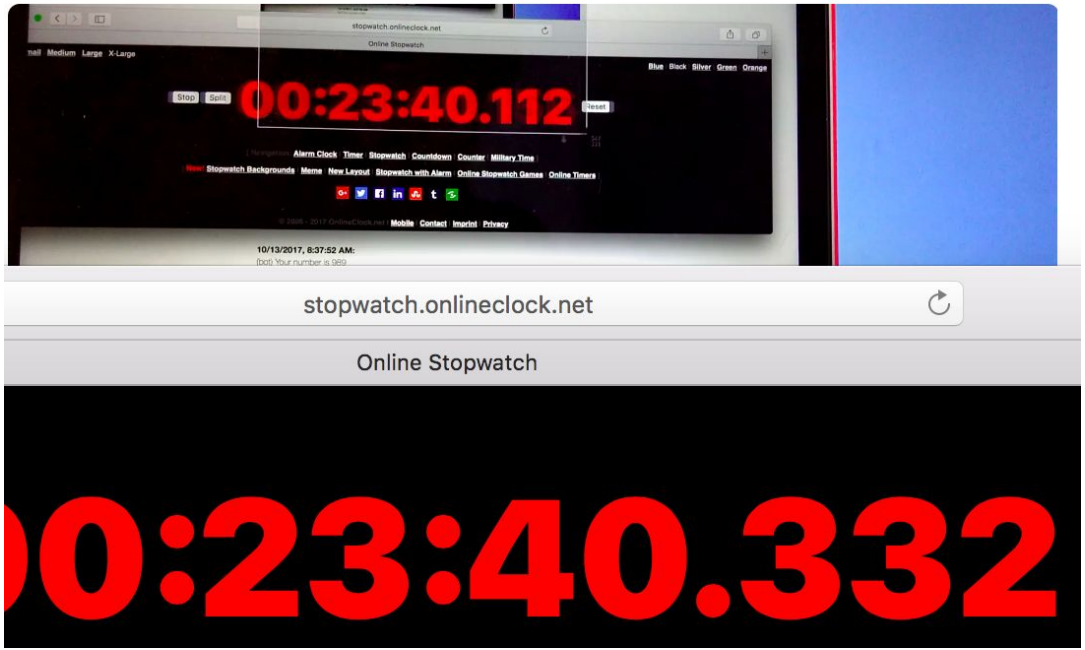
GstShark - Iteration 3

gst-launch-1.0 webrtcbin rtcp-mux=true start-call=false signaler::user-channel=ridgerun name=web latency=0 nvcamerasrc ! "video/x-raw(memory:NVMM),width=1920,height=1080" ! nvvidconv flip-method=rotate-180 ! queue ! cuda ! omxvp8enc ! rtpvp8pay ! web.video_sink web.video_src ! rtpvp8depay ! omxvp8dec ! nvoverlaysink

GstShark - Iteration 3



GstShark - Iteration 3




```
   332
-  112
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   220
```
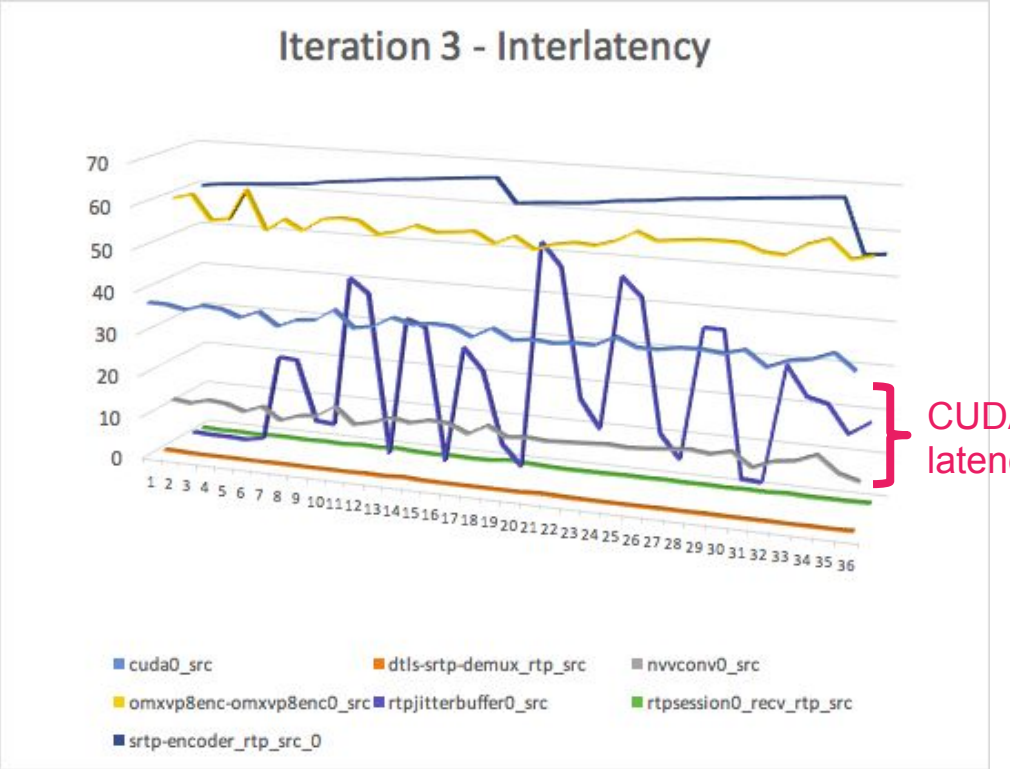

GstShark - Iteration 3

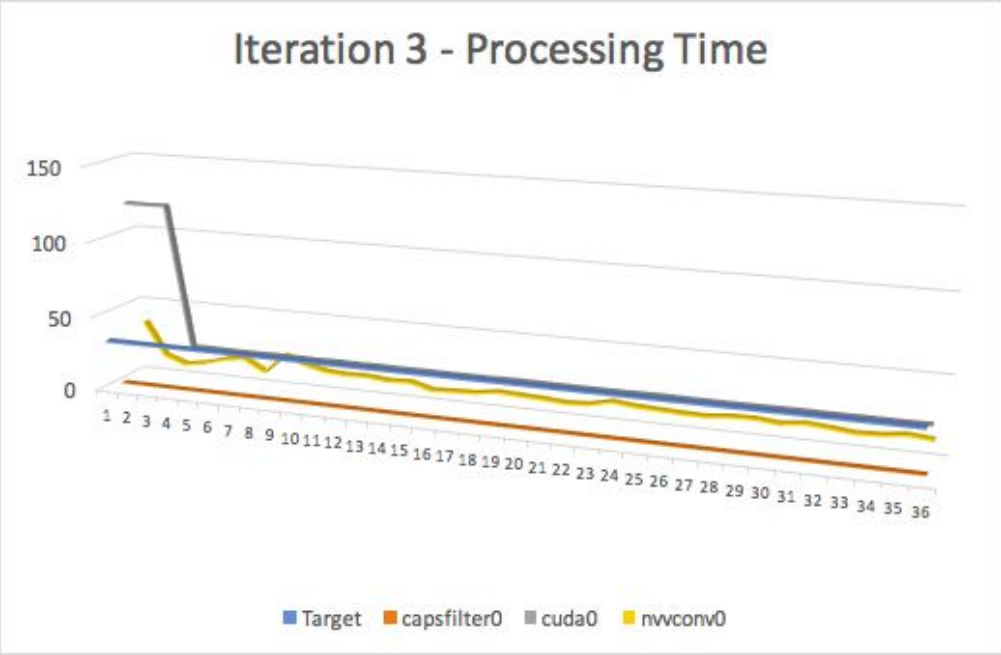
- VP8 Encoder ✓
- Full HD ✓
- 30 FPS ✓
- 200 ms latency ✗

GstShark - Iteration 3



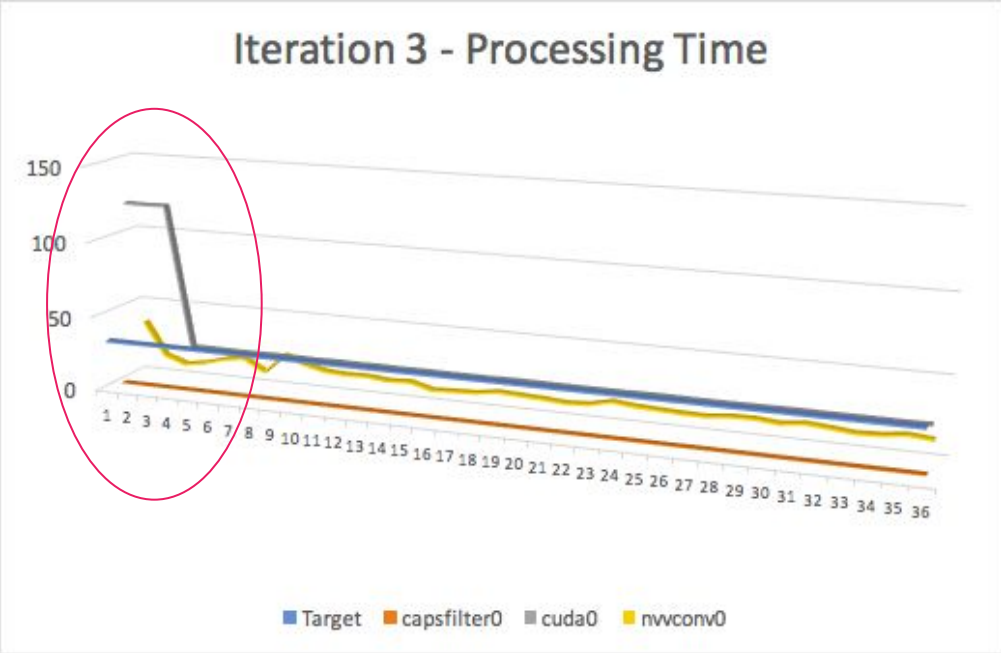
CUDA/Queue latency

GstShark - Iteration 3

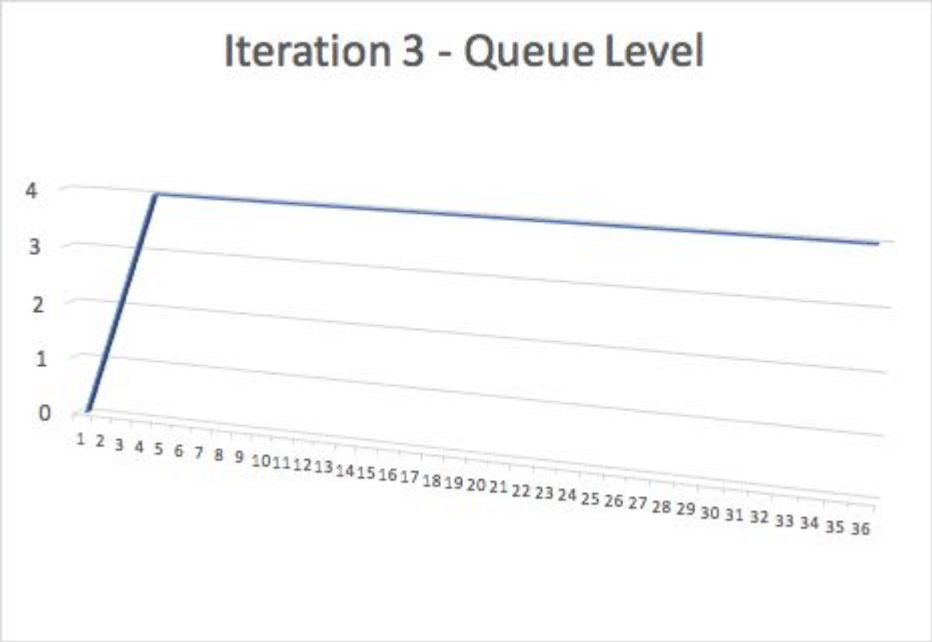


GstShark - Iteration 3

Suspicious spike

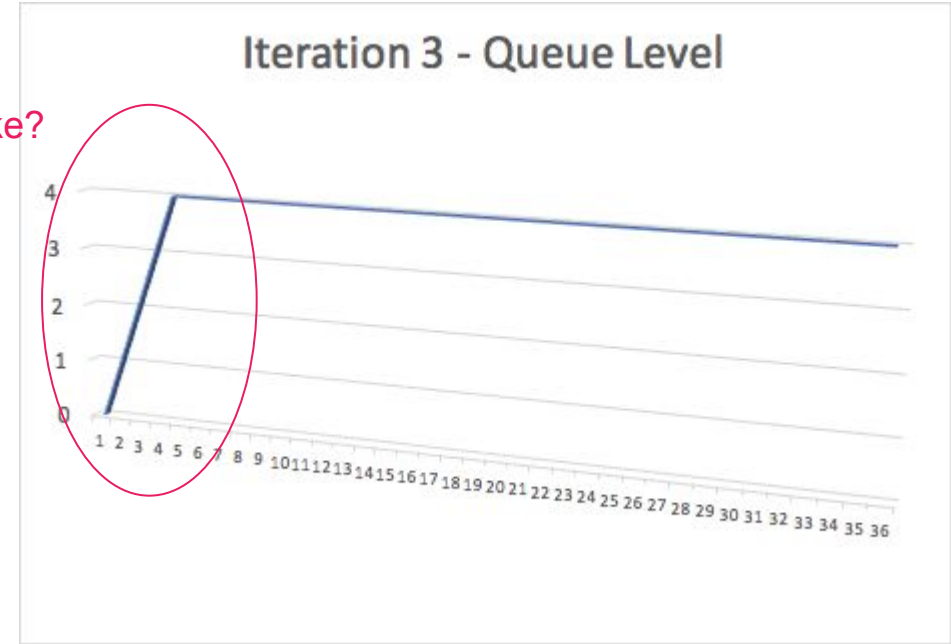


GstShark - Iteration 3

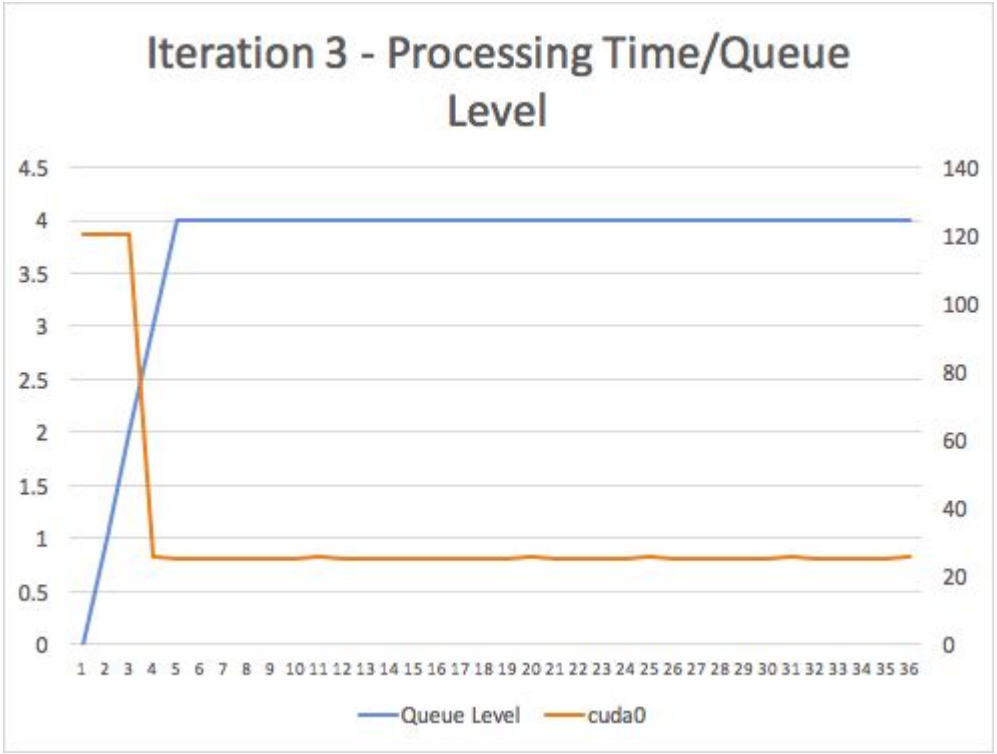


GstShark - Iteration 3

Suspicious spike?

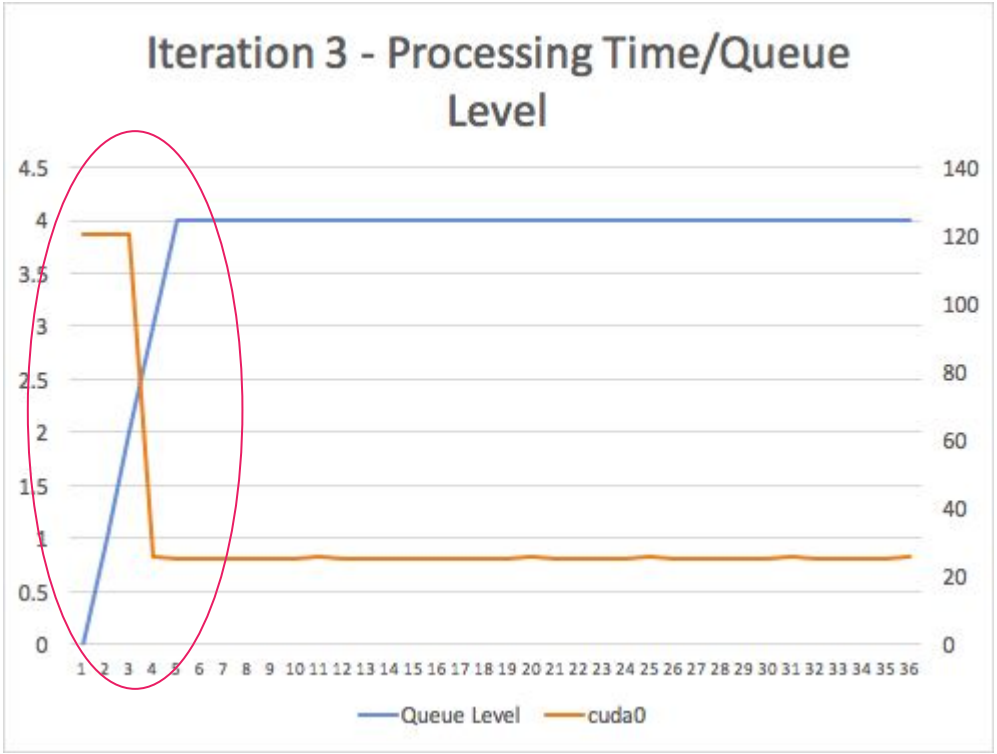


GstShark - Iteration 3

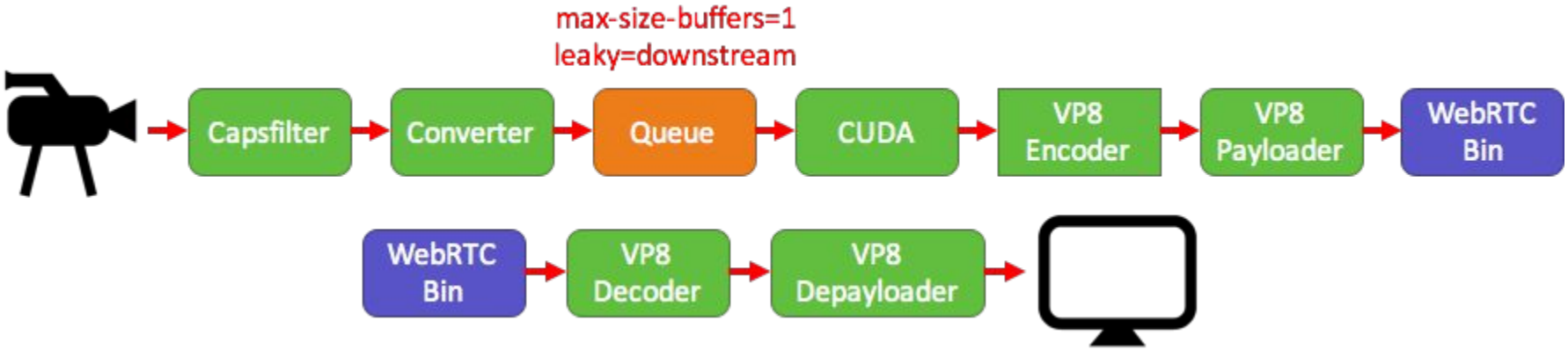


GstShark - Iteration 3

Buffers are queued during startup



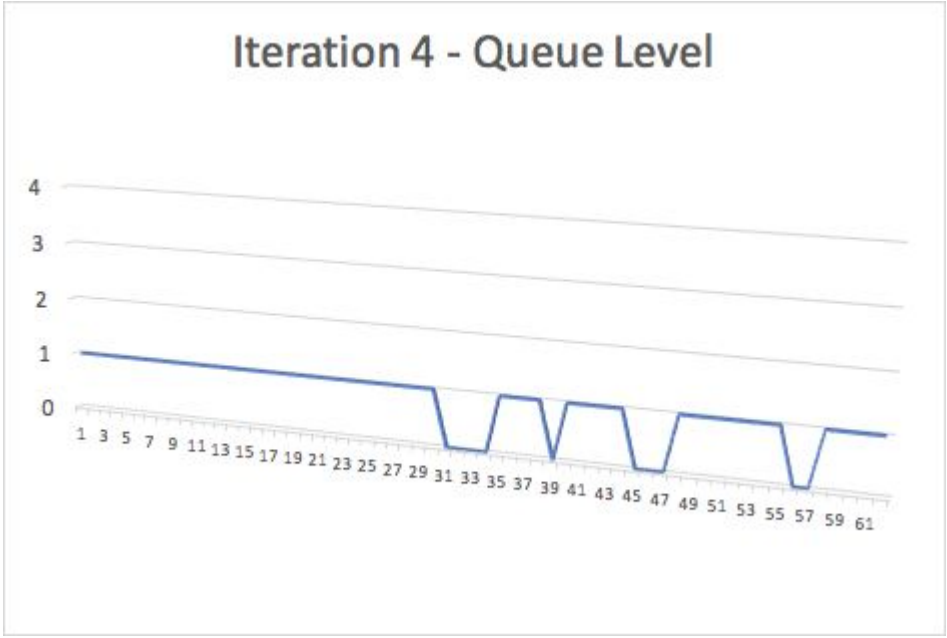
GstShark - Iteration 4



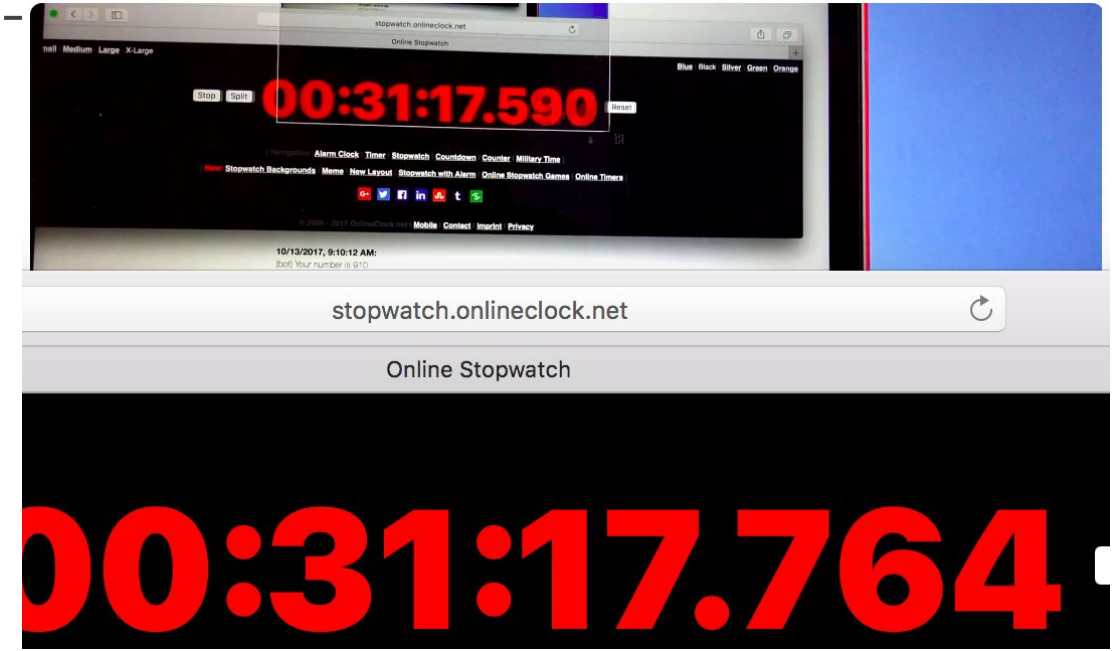
GstShark - Iteration 4

gst-launch-1.0 webrtcbin rtcp-mux=true start-call=false signaler::user-channel=ridgerun name=web latency=0 nvcamerasrc ! "video/x-raw(memory:NVMM),width=1920,height=1080" ! nvvidconv flip-method=rotate-180 ! queue max-size-buffers=1 leaky=2 ! cuda ! omxvp8enc ! rtpvp8pay ! web.video_sink web.video_src ! rtpvp8depay ! omxvp8dec ! nvoverlaysink

GstShark - Iteration 4



GstShark - A Real Life example




```
  764
- 590
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  174
```
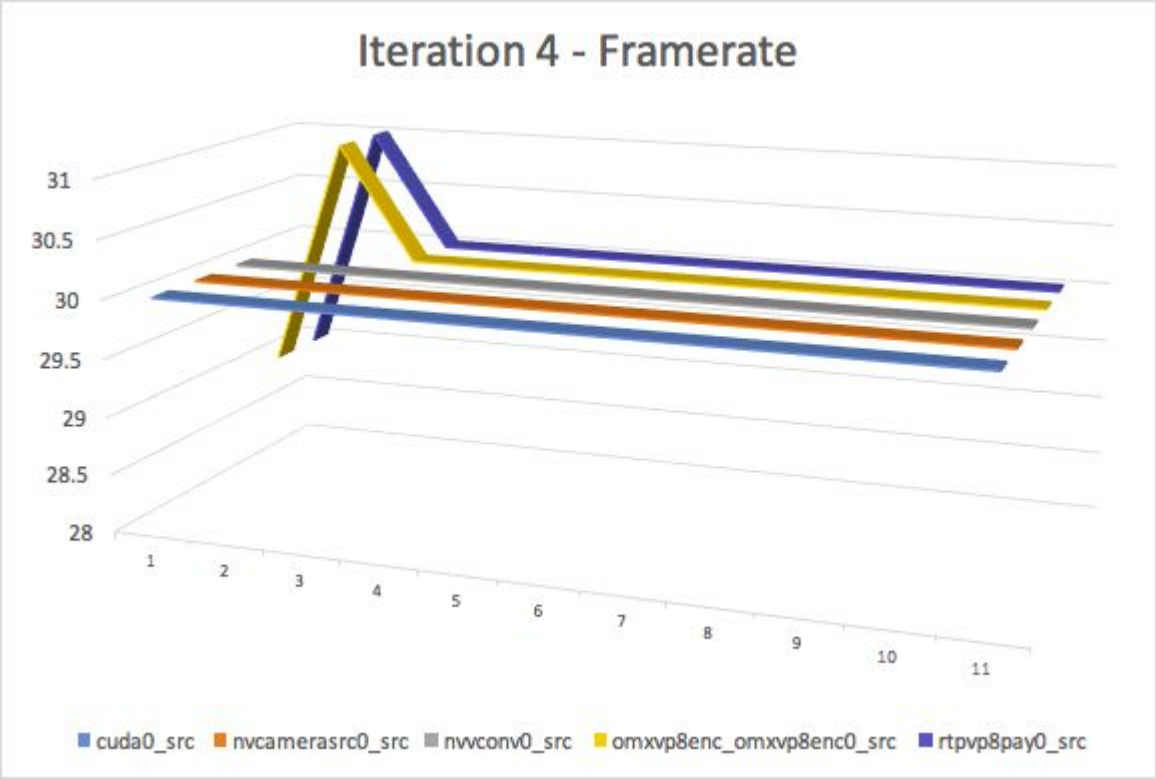
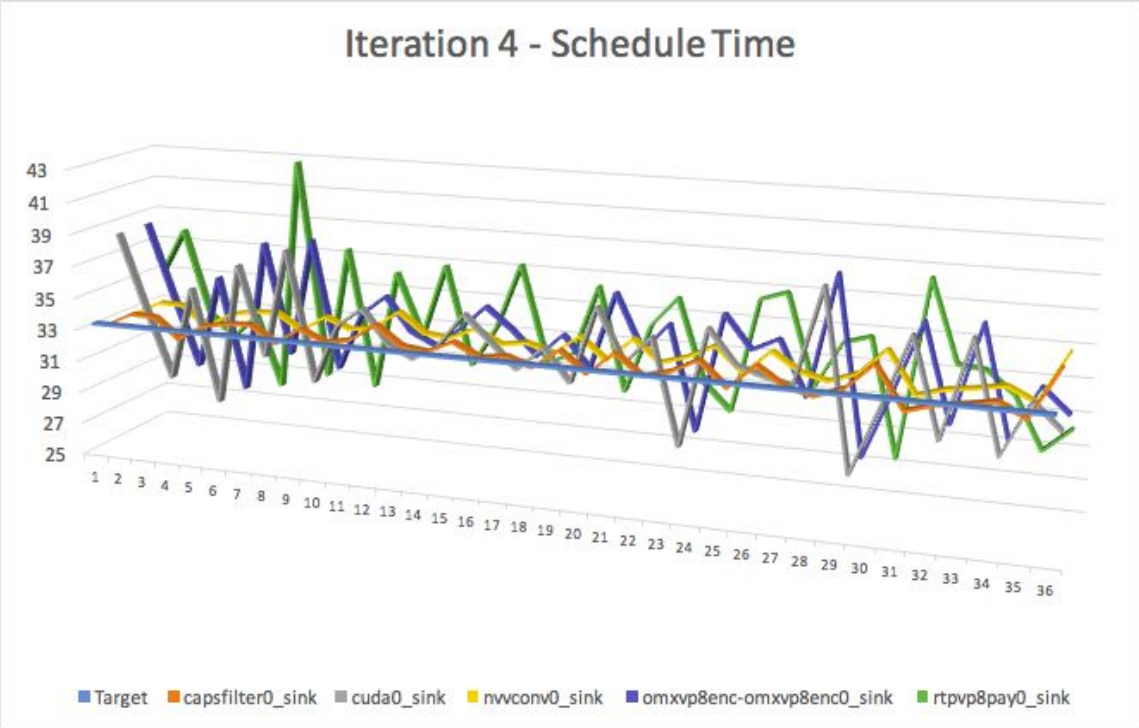

GstShark - Iteration 4

- VP8 Encoder ✓
- Full HD ✓
- 30 FPS ✓
- 200 ms latency ✓

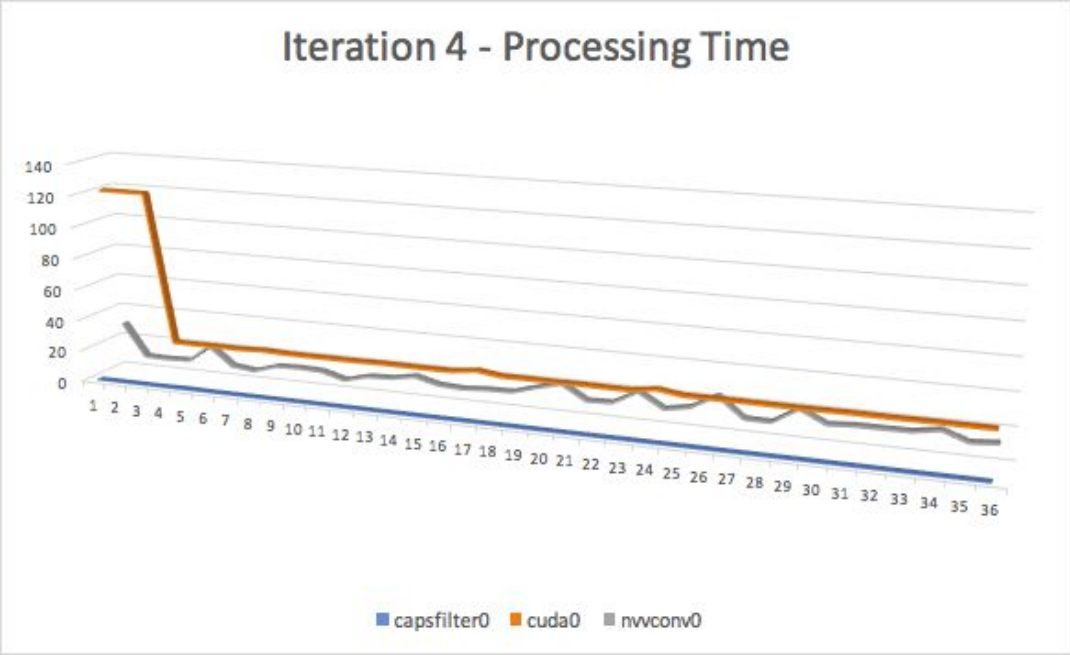
GstShark - Iteration 4



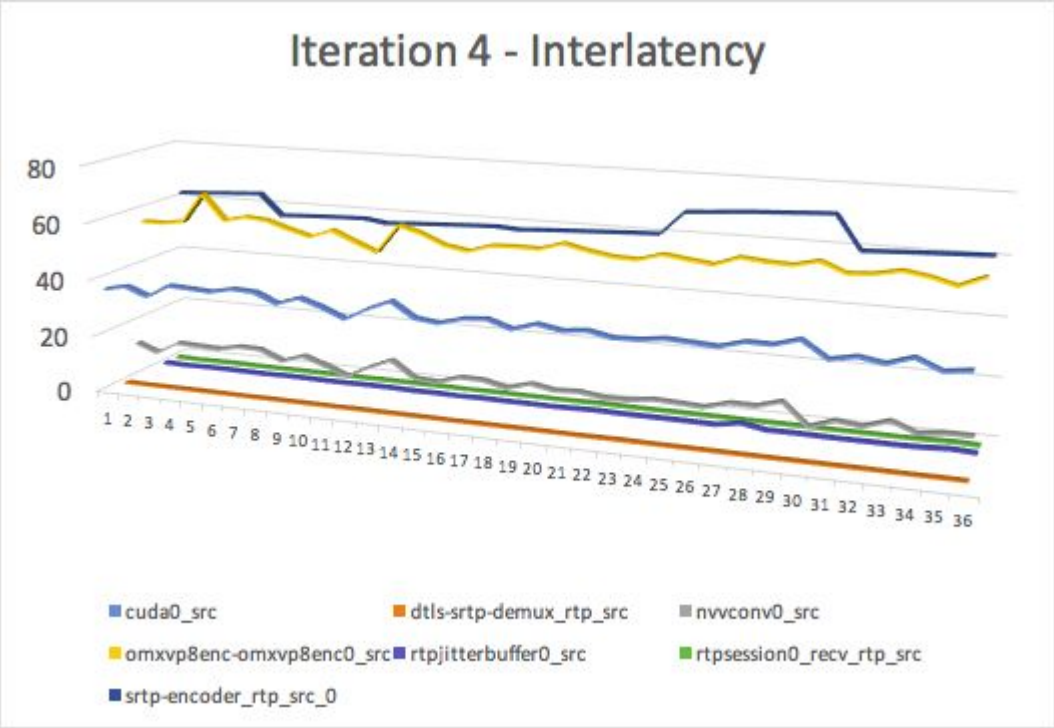
GstShark - Iteration 4



GstShark - Iteration 4



GstShark - Iteration 4



GstShark - Future development (1)

- HW specific tracers:
  - NVIDIA (GPU), Xilinx (FPGA), TI (DSP) and NXP (i.MX6 mem bus utilization) profiling tools usage from tracers
  - Single time reference for debug data and buffers
  - Homogeneous interface
- CPU Tracer improvements
  - Print usage of pipeline only
  - Usage per thread?

GstShark - Future development (2)

- Pass parameters to the tracers currently enabled
  - Supported on GStreamer but not GstShark
  - Do not print info for every pad but ability to select - reduce overhead
- Graphical front-end
  - Filter data
  - Overlap plot to find tendencies
  - Mark outliers
  - Real time plot

Code location and documentation

- GstShark is open source:

  https://github.com/RidgeRun/gst-shark

  https://developer.ridgerun.com/wiki/index.php?title=GstShark

Questions?

support@ridgerun.com

Thank you!