

Intel® Media Server Studio - Metrics Monitor (v1.1.2) Reference Manual

Overview

Metrics Monitor is part of **Intel® Media Server Studio 2018 R2 for Linux***.

Metrics Monitor is a user space shared library which provides applications access to a number of metrics from the GPU kernel mode driver to aid in understanding the state of the GPU for Media workloads.

In this document we will refer to processor families by their former codenames for the sake of readability:

- Intel® Xeon® E3-1200/1500 v5 Family and 6th Generation Intel® Core™ Processors will be referred to as "Skylake"
- Intel® Xeon® E3-1200 v4 Family and 5th Generation Intel® Core™ Processors will be referred to as "Broadwell"

What's New

Intel® Media Server Studio 2018 R2 – Metrics Monitor

Version 1.1.1:

- Support of systems with several GPU. Metrics Monitor detects Intel GPU automatically.

Version 1.1.2:

- Support i915 PMU API to query metrics.
- Support precise engines utilization tracking instead of sampling estimations (requires i915 scheduler).
- Reduced CPU usage overhead in case of precise engines utilization path.

Location and Contents

The Intel® Media Server Studio – Metrics Monitor contains the following components:

<samples-install-folder>/	
samples/_bin/x64/libcttmetrics.so	Metrics Monitor shared library

<code>samples/_bin/x64/metrics_monitor</code>	Pre-build binary of the sample, that uses Metrics Monitor shared library
<code>samples/_bin/x64/test_monitor</code>	Pre-build binary of the metrics monitor test application, that uses Metrics Monitor shared library
<code>samples/metrics_monitor/include</code>	Headers required for building <code>libcttmetrics.so</code> library and <code>metrics_monitor</code> sample
<code>samples/metrics_monitor/src</code>	Sources required for building <code>libcttmetrics.so</code> library
<code>samples/metrics_monitor/sample</code>	Sources required for building <code>metrics_monitor</code> sample
<code>samples/metrics_monitor/test</code>	Sources required for building <code>metrics_monitor</code> test application based on Google test framework
<code>samples/metrics_monitor/metricsmon-man.pdf</code>	Metrics monitor manual

Software Requirements

The Metrics Monitor depends on:

1. Either installing of **Intel® Media Server Studio 2018 R2 – Graphics Driver** provided with the package
2. Or applying the following patch series over the desired kernel:
<https://patchwork.freedesktop.org/series/27488/>

and does not work with other driver versions. Make sure that you build and install kernel-mode driver. For more details how to do it refer to the Intel® Media Server Studio – Driver & SDK Getting Started Guide.

The Metrics Monitor requires special privileges to be able to report metrics. Metrics can be reported either if:

1. User has 'root' privileges
2. Or if /proc/sys/kernel/perf_event_paranoid is less than 1
3. Or if application has CAP_SYS_ADMIN capability

To provide CAP_SYS_ADMIN capability to metrics_monitor (or any other application which uses libctt.so library), do the following:

1. Install libcttmetrics.so to system path (for security reasons LD_LIBRARY_PATH will not work for applications which have capabilities), for example with:

```
$ sudo ln -s /opt/intel/mediasdk/samples/_bin/x64/libcttmetrics.so /usr/lib64
```

2. Execute the following command:

```
$ sudo setcap cap_sys_admin+ep /opt/intel/mediasdk/samples/_bin/x64/metrics_monitor
```

Be aware that the use of any GUI (e.g. X Server) will add additional usage beyond the media workloads to the Blitter and Render engines.

Building the software

To build the Metrics Monitor test application (test_monitor) need to install these packages:

- libpciaccess-devel
- libgtest-devel

Also make sure, that libpciaccess-devel have the latest version.

Running the Software

To run the Metrics Monitor sample application change to root, set the path to the cttmetrics.so library thru `$LD_LOAD_LIBRARY` environment variable and run the application:

```
$ sudo su
$ export LD_LIBRARY_PATH=<metrics_lib_path>:$LD_LIBRARY_PATH
$ ./metrics_monitor
```

where `<metric_lib_path>` is where the `cttmetrics.so` library is installed.

To run the Metrics Monitor test application change to root, set the path to the cttmetrics.so library thru `$LD_LOAD_LIBRARY` environment variable and run the application:

```
$ sudo su
$ export LD_LIBRARY_PATH=<metrics_lib_path>:$LD_LIBRARY_PATH
$ ./test_monitor
```

Architecture

This section describes the architecture of the Metrics Monitor library.

The Metrics Monitor library collects the following i915 kernel mode driver performance counters data:

1. Amount of time each GPU Engine spent executing tasks
2. Average actual GPU frequency

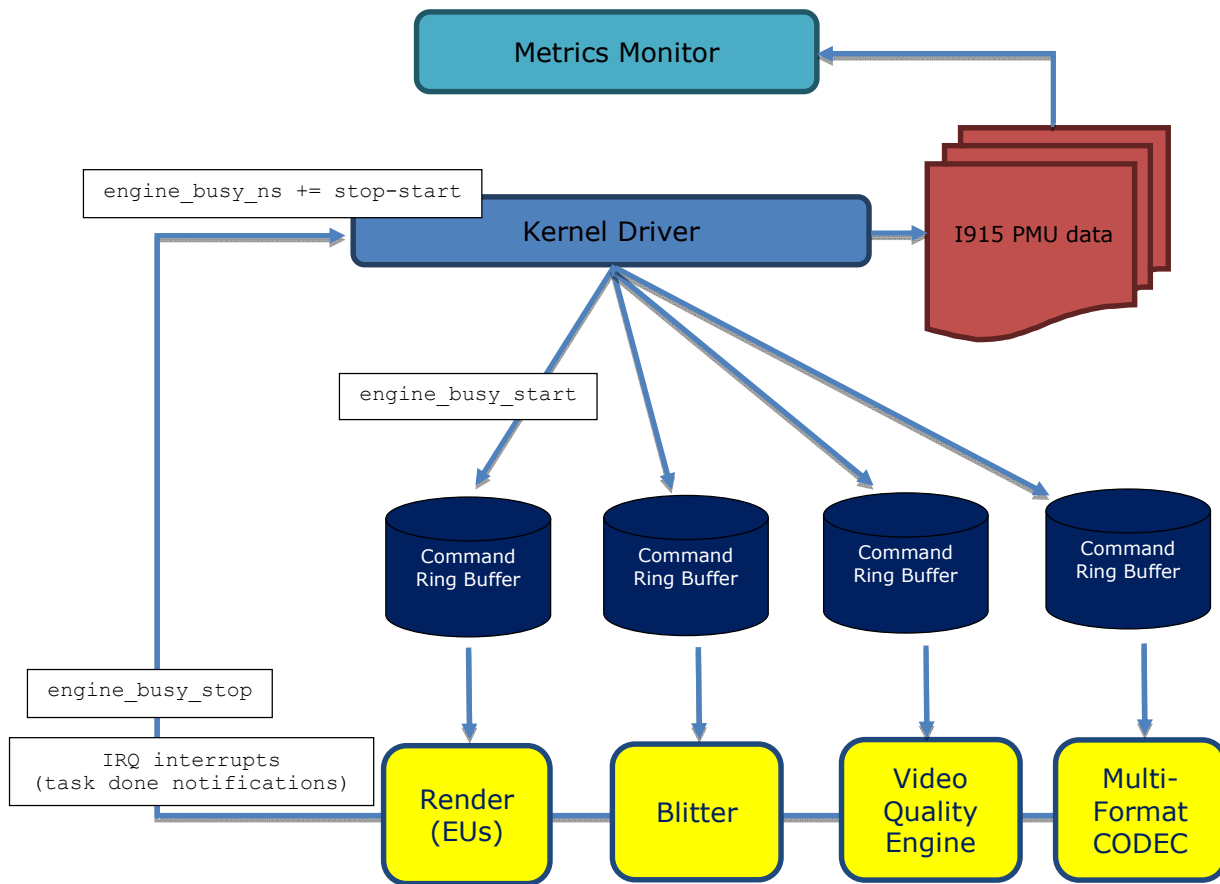
Metrics Monitor allows to monitor the following GPU hardware units (Engines):

- Render engine (execution units)
- Multi-Format CODEC (MFX)
- Video Quality Engine
- Blitter engine

The Intel® GPU provides 4 or 5 command streamers depending on the generation of Intel® Core™ processors. Each command streamer corresponds to one of the GPU Engines. The command streamers pull commands from command ring buffers in memory that the kernel driver populates.

I915 kernel mode driver tracks each request execution, when it was scheduled and when it was completed, and is capable to approximate time each engine spent actively running tasks which is reported as usage by metrics monitor in percent scale [0-100%] over elapsed time period. The described process is illustrated on the following diagram.

Metrics Monitor is also capable to report average actual GPU frequency over elapsed period of time. While Engines Usage metrics are precise metrics, frequency metric is sampled. Sampling period is defined inside i915 PMU and is not currently adjustable by the application. It can be noted however, that sampling is done once in i915 PMU regardless of number of i915 PMU clients (number of metric monitor applications running).

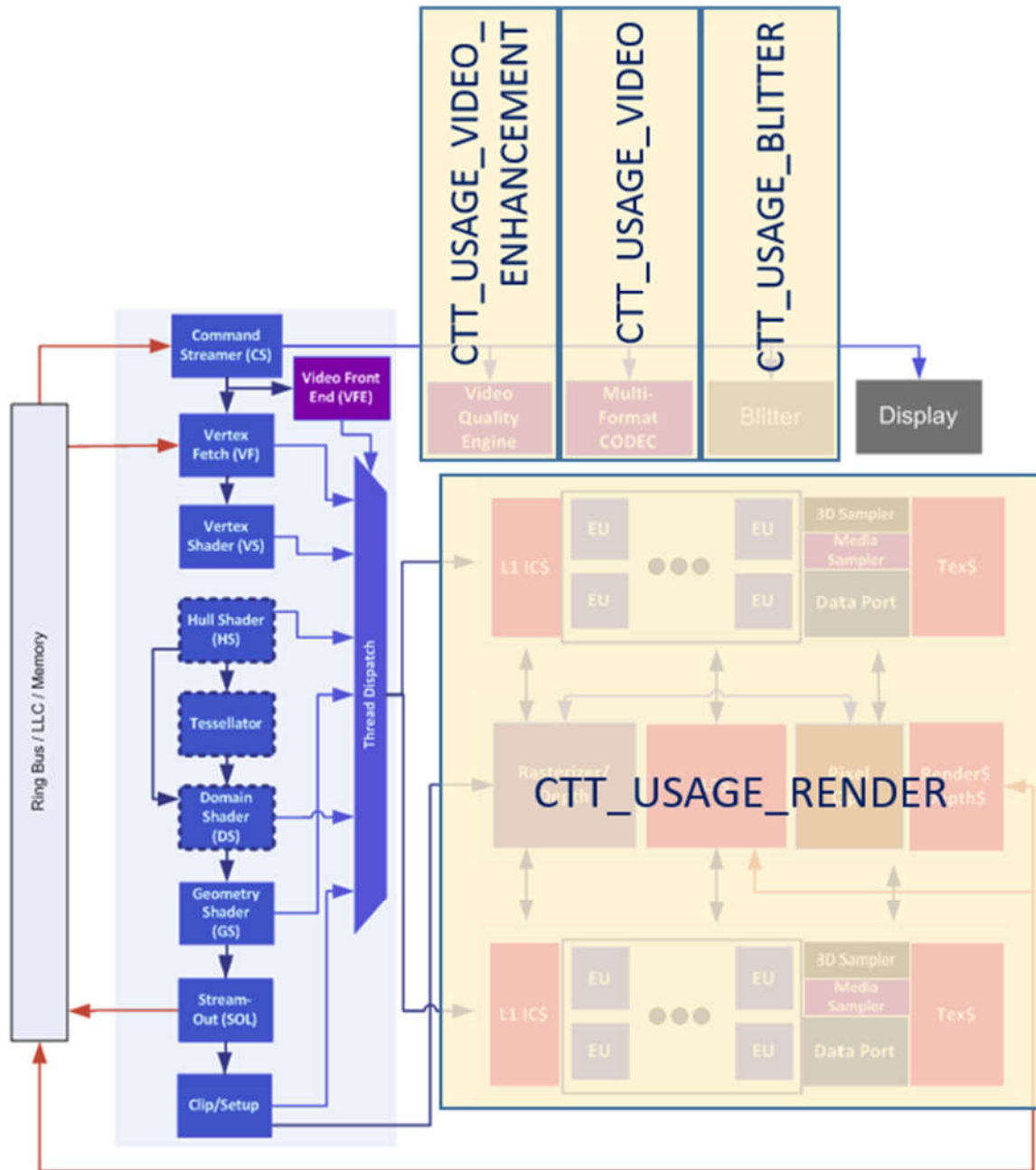


Metrics Description

The table below provides description of metrics supported by the Metrics Monitor.

Metric name from header file	Hardware Units covered	Uses that will execute this unit
CTT_USAGE_RENDER	Render Engine (Execution units, media samplers, VME and their caches)	Video Encode (ENC), OpenCL, Video Scaling, VPP Composition including frame rate conversion and image stabilization, VPP copy to CPU
CTT_USAGE_VIDEO	Multi-Format Codec Engine (also known as "MFX" or "VDBOX")	Video Encode (PAK) and Decode
CTT_USAGE_VIDEO2	2 nd instance of the Multi-Format Codec Engine, if available (Examples of supported processor include 5 th generation of Intel® Core™ processors with Intel® HD Graphics 6000, Intel® Iris® Graphics 6100, Intel® Iris® Pro Graphics 6200, Intel® Iris® Pro Graphics P6300)	Video Encode (PAK) and Decode
CTT_USAGE_VIDEO_ENHANCEMENT	Video Quality Engine (also known as "VEBOX" or Video Quality enhancement pipeline)	Deinterlace, Denoise
CTT_USAGE_BLITTER	2D graphics blitter engine.	2D and 3D Blt (no media use)
CTT_AVG_GT_FREQ	Intel GPU	Any task running on any of the GPU Engines listed above

Below is the example of mapping metrics to the 4th generation of Intel® Core™ processor architecture.



For detailed description of GPU's engines refer to the Intel® Open Source Graphics Programmer's Reference Manual (PRM) for Skylake and Broadwell platforms:

<https://01.org/linuxgraphics/documentation/hardware-specification-prms/2015-2016-intel-processors-based-skylake-platform>

<https://01.org/linuxgraphics/documentation/hardware-specification-prms/2014-2015-intel-processors-based-broadwell-platform>

Usage Model

This section provides overview of possible usages of the Metrics Monitor.

The Metrics Monitor tool can be used for monitoring GPU metrics. Different scenario of the Metrics monitor usages provided below. All sample applications referenced below can be found in the SDK sample package, which is part of Intel® Media Server Studio product.

A. Video engine usage during decoding

1. Run Metrics Monitor sample application. It begins collecting metrics from GPU.
2. Run `sample_decode` application to perform decoding of h264 stream to put a load on GPU.
3. Observe that video usage metric shows how video engine was busy performing decoding.

Example of command line to perform decoding:

```
$ ./sample_decode h264 -hw -vaapi -async 4 -i ../streams/bbb1920x1080.264
```

B. Video Enhancement pipeline usage during video processing

1. Run Metrics Monitor sample application. It begins collecting metrics from GPU.
2. Run `sample_vpp` application to perform de-interlacing of interlaced stream using advanced capabilities of video enhancement pipeline.
3. Observe that video enhancement usage metric shows how video enhancement pipeline was busy performing de-interlacing.

Example of command line to perform video processing with advanced de-interlacing:

```
$ ./sample_vpp -lib hw -vaapi -sw 1920 -sh 1080 -dw 1920 -dh 1080 -spic 0 -dpic 1 -di_mode 2 -i i_stream.nv12 -o p_stream.nv12
```

C. Video and Render engine usage during transcoding

1. Run Metrics Monitor sample application. It begins collecting metrics from GPU.
2. Run `sample_multi_transcode` application to perform transcoding from one format to another and with different transcoding speed to put a load on GPU.
3. Look for video and render usage metrics provided by the Metrics Monitor and run more workloads to observe how metrics value changes. Video engine usage scales with increasing or decreasing number of workloads.

Example of command line to perform transcoding:

```
$ ./sample_multi_transcode -i::h264 bbb1920x1080.264 -o::mpeg2 bbb1920x1080.mp2 -hw -async 4 -fps 15
```

Limitations

This section describes limitations of the Metrics Monitor.

- The metrics are not normalized for GPU operating frequency and the metric values may change according to frequency change.
- Engines usage metrics provide approximation of the real Engines usages and may not be fully accurate due to scheduling notification latencies.
- Due to sampling nature of Average Frequency metric its values may not be fully accurate and provide only estimation of real average frequency.

API Reference

This section describes the Metrics Monitor API.

CTTMetrics_Init

Syntax

```
cttStatus CTTMetrics_Init();
```

Description

This function initializes media metrics library.

Return Status

MFX_ERR_NONE	Metrics Monitor library succesfully initialized.
--------------	--

CTTMetrics_GetMetricCount

Syntax

```
cttStatus CTTMetrics_GetMetricCount(unsigned int* out_count);
```

Parameters

out_count	Number of metrics available.
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Description

This function sreturns the number of available metrics. Must be called after CTTMetrics_Init().

Return Status

MFX_ERR_NONE	Number of available metrics returned successfully.
--------------	--

CTTMetrics_GetMetricInfo

Syntax

```
cttStatus CTTMetrics_GetMetricInfo(unsigned int count, cttMetric* out_metric_ids);
```

Parameters

count	Number of elements in the out_metric_ids.
out_metric_ids	Output array of available metric IDs. Must be allocated and de-allocated by app.

Description

This function returns IDs of available metrics. Must be called after CTTMetrics_Init().

Return Status

MFX_ERR_NONE	Metrics IDs returned succesfully.
--------------	-----------------------------------

CTTMetrics_Subscribe

Syntax

```
cttStatus CTTMetrics_Subscribe(unsigned int count, cttMetric*  
in_metric_ids);
```

Parameters

count	Number of metrics to collect.
in_metric_ids	Input array of metric IDs.

Description

This function specifies metrics being collected. Must be called after CTTMetrics_Init().

Return Status

MFX_ERR_NONE	Metrics subscription completed succesfully.
--------------	---

CTTMetrics_SetSampleCount

Syntax

```
cttStatus CTTMetrics_SetSampleCount(unsigned int in_num);
```

Parameters

in_num	Number of metric samples to collect during sampling period.
--------	---

Description

Sets the number of metric samples to collect during sampling period. Default = 100. Valid range 1..1000. Must be called after CTTMetrics_Init().

Return Status

MFX_ERR_NONE	Number of samples set successfully.
--------------	-------------------------------------

CTTMetrics_SetSamplePeriod

Syntax

```
cttStatus CTTMetrics_SetSamplePeriod(unsigned int in_period);
```

Parameters

<code>in_period</code>	Sampling period in milliseconds.
------------------------	----------------------------------

Description

Sets the sampling period in milliseconds to collect metric samples. Default = 500. Valid range 10..1000. Must be called after CTTMetrics_Init().

Return Status

<code>MTX_ERR_NONE</code>	Sampling period set successfully.
---------------------------	-----------------------------------

CTTMetrics_Close

Syntax

```
void CTTMetrics_Close();
```

Description

Close media metrics library and stops metrics collection.

CTTMetrics_GetValue

Syntax

```
cttStatus CTTMetrics_GetValue(unsigned int count, float*  
out_metric_values);
```

Parameters

<code>count</code>	Number of metric values to receive.
<code>out_metric_values</code>	Output array of metric values (floats). Must be allocated and de-allocated by app. <code>out_metric_values[i]</code> corresponds to <code>in_metric_ids[i]</code> in CTTMetrics_Subscribe().

Description

This function returns metric values. Number of values equals to `*count*` - number of metric ids in CTTMetrics_Subscribe().

Return Status

<code>CTT_ERR_NONE</code>	Metric values received successfully.
---------------------------	--------------------------------------

Appendix – A (version 1.1.1 notes)

Version 1.1.1 of metrics monitor library used another approach of getting metrics. This metrics collector still remains in metrics monitor library for the backward compatibility. For this reason current Appendix contains detailed notes on the software requirements and implementation of Version 1.1.1 metrics collector.

Software Requirements

The Metrics Monitor Version 1.1.1 data collector depends on installing **Intel® Media Server Studio 2017 R3 – Graphics Drivers (or earlier version)** and does not work with other driver versions. Make sure that you build and install kernel-mode driver. For more details how to do it refer to the Intel® Media Server Studio – Driver & SDK Getting Started Guide.

The Metrics Monitor requires the “root” user privileges and `debugfs` file system set up on your machine.

```
$ # mount | grep debugfs
```

To check if `debugfs` is mounted:

```
$ # mount -t debugfs nodev /sys/kernel/debug
```

If you don't have `debugfs` mounted:

For most accurate results it's expected to run in headless operation. The use of any GUI (e.g. X Server) will add additional usage beyond the media workloads to the Blitter and Render engines.

Architecture

This section describes the architecture of the Metrics Monitor library version 1.1.1 data collector.

The Metrics Monitor library collects statistical information from GPU kernel driver about ring command buffers of different GPU units. The driver provides information if the command ring buffer was in idle state or not in particular time. The driver exposes this information via `debugfs` file system. Command ring buffer idle state is the state when it's empty and doesn't have any commands to pull and execute by GPU.

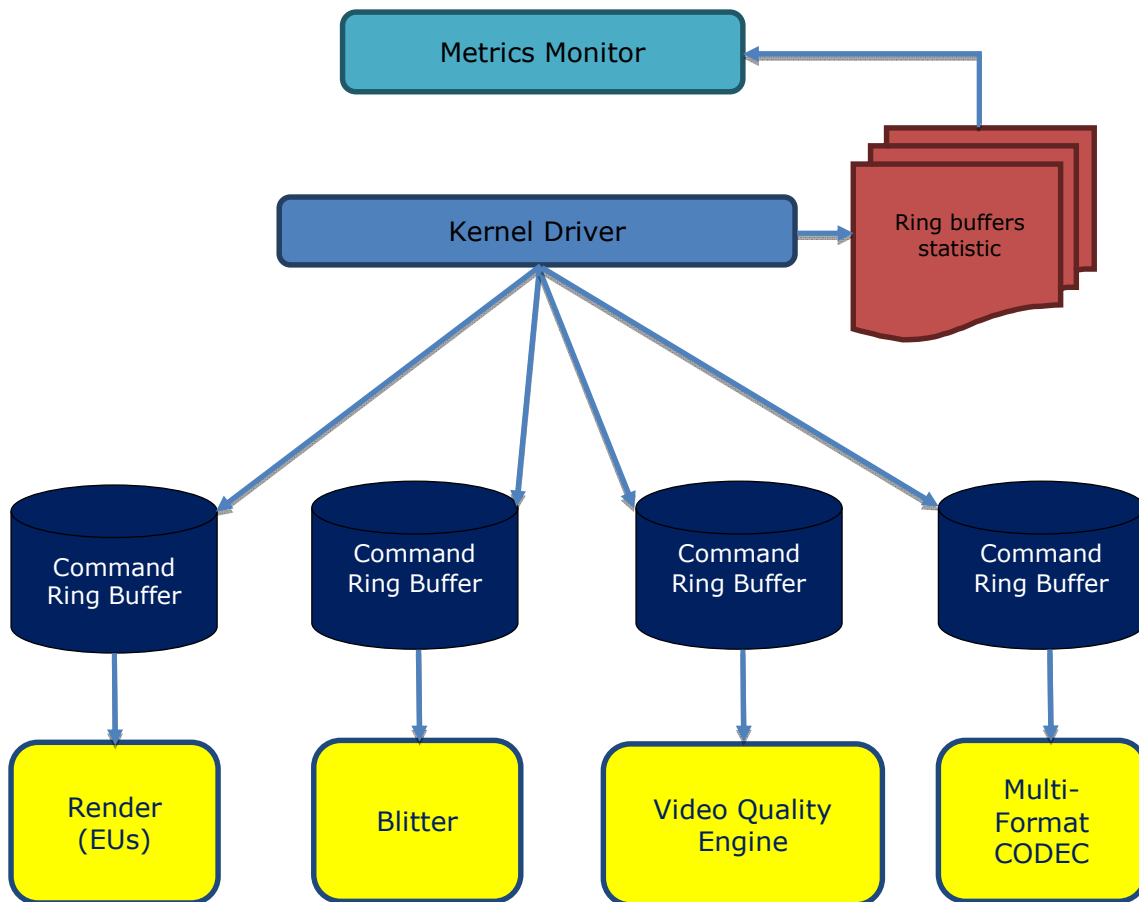
Metrics Monitor allows to monitor the following GPU hardware units:

- Render engine (execution units)

- Multi-Format CODEC (MFX)
- Video Quality Engine
- Blitter engine

The Intel® GPU provides 4 or 5 command streamers depending on the generation of Intel® Core™ processors. The command streamers pull commands from command ring buffers in memory that the kernel driver populates.

An overview of this process is shown in figure below:



The usage of particular GPU unit is estimated according to the following data – “how much time the command ring buffer was in idle state during the sampling period”.

The Metrics Monitor allows to collect metrics data within user defined sampling period.

During the sampling period the Metrics Monitor collects the number of idle states for command ring buffer and calculates the busy metrics as relation of number of busy states to the number of all states. Number of states collected during the sampling period can be 1000 or less depending on the performance of obtaining and processing data from driver and the number of samples a user defined to collect.

Limitations

This section describes limitations of the Metrics Monitor version 1.1.1 data collector.

- The metrics are not normalized for GPU operating frequency and the metric values may change according to frequency change.
- The small workloads with processing time less than the duration of sampling period cannot be monitored.
- Due to statistical nature of metrics measurement on Linux the metric values may have big deviations.
- Sampling metrics may introduces performance impact to the media processing and total CPU Usage and Power Consumption.

The following table provides the overhead data for 100 millisecond sampling period.

	CPU usage, %	Processing time, sec	Processing speed, fps	Overhead, %
No Metrics Monitor	0	69.6	30.7	0
20 samples	1	70.2	30.5	0.7
100 samples	3	71.5	29.9	3.0
500 samples	8	72.7	29.4	4.4
1000 samples	13	74.4	28.7	6.8

The sampling overhead measurements were done using `sample_multi_transcode` application, which run in the N to N transcoding mode. It performs 10 joined transcoding sessions converting Full HD H264 streams to H264 Full HD streams. One stream containing 2136 frames was used as input stream for all transcoding sessions.

The “CPU usage” information was collected by “top” tool on the system without any media workloads and shows only impact introduced by metrics sampling in the Metrics Monitor.

The measurements were done on the CentOS 7 system with Intel® Core™ i7-4770K processor and enabled Turbo Boost (Max frequency 3.9 GHz) and processor graphics frequency fixed at 1350 MHz.

Appendix – B

The following table provides comparison of metrics monitor CPU Usage overhead between Versions 1.1.1 and 1.1.2 on 100ms sampling period.

	Version 1.1.1 CPU Usage, %	Version 1.1.2 CPU Usage, %
No Metrics Monitor	0	0
20 samples	1	0.4
100 samples	3	0.4
500 samples	8	0.4
1000 samples	13	0.4

Version 1.1.2 does not require samples within sampling period to get correct metrics, thus CPU Usage remains constant on any number of samples. Still metrics monitor Version 1.1.2 may have some CPU Usage overhead mostly defined by the requested sampling period.

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