



EMON User Guide

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Revision History

Revision Number	Description	Revision Date
1.0	Initial release.	January 2013
2.0	Completed major documentation updates and renamed to EMON User's Guide. Added Installation and Examples chapters. Updated examples in section 2.2 General Options: Collection.	February 2016
2.1	Added and removed event modifiers.	February 2017
2.2	Updated SEP driver version.	April 2017
2.3	Updated examples in chapters 3 and 4.	September 2017
2.4	Updated the guide with missing options and added description where required.	June 2018
2.5	Minor updates to commands.	February 2019
2.6	Added "Collect and Process EDP Metrics" section	April 2022
2.7	Dropped -process-edp option	April 2023
2.8	Added details about data collection on hybrid platforms	August 2023
2.9	Added -per-cpu-absolute-tsc option details	October 2023

About This Document

EMON is a low-level command-line tool that provides the ability to profile application and system performance. The tool leverages counters from hardware Performance Monitoring Units (PMUs) to collect performance monitoring events.

Users have the option of specifying hardware events and attributes. EMON allocates and configures the required event resources in the PMU to retrieve event counts from the processor core and uncore. The tool collects the number of occurrences of selected events for the duration of collection.

Intended Audience

Related Information

For information on Performance Monitoring Unit (PMU), go to <http://www.intel.com/content/www/us/en/processors/architectures-software-developer-manuals.html>.

Usage

Use EMON with the following syntax:

```
emon [general-options] -C "event-definitions" [application-command-line]
```

The following example collects event data for `INST_RETIRE`.ANY and `BR_INST_RETIRE`.ALL_BRANCHES for a default duration of 3 s:

The output from EMON can be visualized as a table with multiple columns, as shown in the following image:

```
-bash-4.2$ emon -C "INST_RETIRE.ANY,BR_INST_RETIRE.ALL_BRANCHES"
Version Info: public V10.1.0 (Feb  1 2018 at 10:02:03) Intel(R) Processor code n
amed Skylake M:94 S:0

INST_RETIRE.ANY          6,624,328,106    274,851,528    471,225 42,430,304    2
7,446,155    34,653 18,628,052    693,730 584,915
BR_INST_RETIRE.ALL_BRANCHES    6,624,328,106    68,725,647    87,641 7,221,01
5    5,068,433    6,467 3,438,193    122,322 119,968
=====
3.000s real
```

The first column of EMON output contains the event name, and the second column contains clockticks spent during collection duration (6,624,328,106 in our example) followed by event counts on each processor core/uncore unit. In this example, the platform contains eight logical cores. An event count column corresponds to each core.

Informative Options

This section lists all EMON options with examples to illustrate the behavior of certain options.

-h [-list-event-modifiers]

Display help information. The tool lists and describes all supported event modifiers if the sub-option `-list-event-modifiers` is specified. For details on event modifiers, see [Event Modifiers](#).

-pmu-types [available]

Display the PMU types supported by the platform. Add the 'available' parameter to display PMU types available on the current system.

-1 [pmu-type] [-experimental | -all]

List the event names that can be monitored on the host platform. This command excludes events that are not available in the system even though the tool supports their collection. For example, if a system does not have an FPGA, all events related to FPGA are ignored.

```
-bash-4.2$ emon -1
INST_RETIRE.ANY
CPU_CLK_UNHALTED.THREAD
CPU_CLK_UNHALTED.THREAD_ANY
CPU_CLK_UNHALTED.REF_TSC
LD_BLOCKS.STORE_FORWARD
LD_BLOCKS.NO_SR
...
```

Event list can be filtered by adding a PMU type from `-pmu-types` command. For example:

```
emon -l core
```

Experimental events are those events that have not been validated in hardware. To list experimental along with regular events, use the following command:

```
emon -l -experimental
```

To list all events that the tool supports on the current platform, use the following command:

```
emon -l -all
```

NOTE With `-all` option, the command lists experimental events, deprecated events, template events, and all other events enabled for the given platform.

-? | -H [pmu-type] [-experimental | -all]

Print events that can be monitored on the host platform along with a brief description. This command excludes events that are not available in the system even though the tool provides support for them. For example, if a system does not have an FPGA, all events related to FPGA are ignored.

```
-bash-4.2$ emon -?
INST_RETIRED.ANY
    Instructions retired from execution.
CPU_CLK_UNHALTED.THREAD
    Core cycles when the thread is not in halt state
CPU_CLK_UNHALTED.THREAD_ANY
    Core cycles when at least one thread on the physical core is not in halt
state.
```

Event list can be filtered by adding a PMU type from `-pmu-types` command.

For example:

```
emon -? core
```

Experimental events are those events that have not been validated in hardware. To list experimental along with regular events, use the following command:

```
emon -? -experimental
```

To list all events that the tool supports on the current platform, use the following command:

```
emon -? -all
```

NOTE This command lists experimental events, deprecated events, template events, and all other events enabled for the given platform.

-! <event name>

Print description of a given event.

```
-bash-4.2$ emon -! INST_RETIRED.ANY
INST_RETIRED.ANY
    Instructions retired from execution.
```

If the given event does not have the relevant hardware support in the current system, EMON displays a warning saying that the event is not available for collection in the system.

--dry-run

Lists event groups with names of events that will be scheduled together. In the following example, EMON splits the command execution into two runs. The first execution includes events under Event Set 0, and second execution includes those under Event Set 1.

```
-bash-4.2$ emon --dry-run -C "INST_RETIRED.ANY, LONGEST_LAT_CACHE.REFERENCE; BR_IN
ST_RETIRED.ALL_BRANCHES, BR_MISP_RETIRED.ALL_BRANCHES"
Event Set 0
    INST_RETIRED.ANY
    LONGEST_LAT_CACHE.REFERENCE
Event Set 1
    BR_INST_RETIRED.ALL_BRANCHES
    BR_MISP_RETIRED.ALL_BRANCHES
```

-M

Print the operating system (OS) processor to hardware logical/physical processor mapping.

-v [-display-features]

Display build and version information of the tool along with other details about the hardware platform. This option also prints the mapping of the OS processor to the logical/physical processor of the hardware. Use the `-display-features` option with this command to display the capabilities supported in this version of driver.

```
-bash-4.2$ emon -v
EMON Version ..... V10.1.0 (public)
Copyright(C) 1993-2018 Intel Corporation. All rights reserved.
Application Build Date: Feb  1 2018 at 10:02:03
SEP driver version: 4.1.0
PAX Driver Version: 1.0.2
total_number_of_processors ..... 8
number_of_online_processors ..... 8
cpu_family ..... Intel(R) Processor code named Skylake
cpu_model ..... 94 (0x5e)
cpu_stepping ..... 0 (0)
L1 Data Cache ..... 32KB, 8-way, 64-byte line size
                        2 HW threads share this cache, No SW Init Required
...
Processor Features:
    (Thermal Throttling) (Enabled)
...
RAM Features:
    (Package/Memory Controller/Channel)
        (0/0/0) (Total Number of Ranks on this Channel: 1)
            (Dimm0 Info: Capacity = 4 GB, Data Width = 8, Form Factor = DIMM, Memory Type = Synchronous, Speed = 2133MHz)
...
TSC Freq ..... 2200.00 MHz

CPU Freq (detected) ..... 2208.00 MHz

                OS Processor <-> Physical/Logical Mapping
                -----
                OS Processor    Phys. Package    Core    Logical Processor
                0                0                0        0
                1                0                1        0
```

Event Collection Options

EMON collects event data for processor core and uncore. This section lists all EMON options related to data collection with examples to illustrate the behavior of certain options.

-C <event1,event2,...>

Specify one or more events for which the performance data will be collected. Events to monitor can optionally be embedded within double-quotes (") and should be separated by a comma (,). Both core and uncore events can be specified for monitoring. However, when user specifies only uncore events in the command line, the tool collects all the fixed core events along with the specified uncore events.

```
-bash-4.2$ emon -C "INST_RETIREDA.NY,BR_INST_RETIREDA.ALL_BRANCHES"
Version Info: public V10.1.0 (Feb  1 2018 at 10:02:03) Intel(R) Processor code named Skylake M:94 S:0

INST_RETIREDA.NY          6,624,328,106    274,851,528    471,225 42,430,304    2
7,446,155    34,653 18,628,052    693,730 584,915
BR_INST_RETIREDA.ALL_BRANCHES    6,624,328,106    68,725,647    87,641 7,221,01
5    5,068,433    6,467 3,438,193    122,322 119,968
=====
3.000s real
```

Data Collection and Event Multiplexing

The number of events that can be monitored simultaneously in a single run is limited by the number of hardware performance counters in the PMU of a processor. Certain events have restrictions that disallows their programming in all counters.

To overcome the limitation of available performance counters on the hardware, EMON splits events into multiple event groups. Each group consists of events that can be collected simultaneously in a single run. The tool schedules an independent data collection for each event group. Events are split in to multiple groups under following two conditions:

- If all events specified in the command line cannot fit into available performance counters on the platform, the tool automatically splits them in to multiple groups.
- User can control splitting of events in to groups while specifying event lists in the command line. To do so, use a semicolon to demarcate group separation instead of using a comma. To understand this use case, see [Multi-group Core Events](#).

Event Modifiers

Individual core/uncore event behavior can be modified using modifiers. The `[:modifier=val]` option enables you to specify individual event modifiers along with the respective values for a given platform.

Event modifiers are attached to event names delimited by a colon (:). They may or may not take values. Where applicable, values are of the following format: `<yes/no>`, `<0/1>`, `<dec/hex values>`. In some special cases explicitly mentioned, they could take other string values.

Basic Event Modifiers

The following table lists the basic event modifiers and provides a short description of each modifier.

Modifier	Description
<code>:USER :usr=<0/1></code>	Specifies that events are counted only when the processor is operating at privilege levels 1, 2, or 3. This flag can be used in conjunction with the SUP flag.
<code>:SUP :os</code>	Specifies that events are counted only when the processor is operating at privilege level 0. This flag can be used in conjunction with the USER flag.
<code>:ALL</code>	Event data is collected regardless of the current privilege level.
<code>:cp</code>	In Check Point. When this modifier is specified, the data result will not include counts that occurred inside of an aborted Intel® Transactional Synchronization eXtensions (Intel® TSX) region.
<code>:tx</code>	In Transaction. When this modifier is specified, the data result will only include counts that occurred inside an Intel® TSX region, regardless of whether that region was aborted or committed.
<code>:perf_metrics</code>	Enable hardware based top-down metrics. This modifier is ignored on all events except for the fixed event <code>TOPDOWN.SLOTS</code> .
<code>:ocr_msr_val=<value></code>	Override the default offcore MSR programming with the user specified value for the event.

Advanced Event Modifiers

The following table lists the event modifiers for more advanced users with an understanding of hardware PMU.

Modifier	Description
:amt<0/1>	Sets (1) or clears (0) the event's Any Thread control bit. A value of 0 causes the event to be counted on a per logical core basis, when applicable. A value of 1 causes the event to be counted on a per physical core basis. Please note that this feature is not supported on 10th generation Intel Core Processors and 3rd generation Intel Xeon Scalable Processors or newer.
:c<cmask> :cmask=<cmask>	Value that will be compared to the count of the specified event during a single cycle per core. If the event count is greater than or equal to this value, the counter is incremented by one; otherwise, the counter is not incremented. The value must be in the range of 0x0 to 0xff.
:e<0/1>	Enables (when set) edge detection of the selected microarchitectural condition. The logical processor counts the number of deasserted to asserted transitions for any condition that can be expressed by the other fields. For example, <pre>emon -l1 -t0.1 -C "MACHINE_CLEAR.S.COUNT, MACHINE_CLEAR.S.COUNT:e1:c1"</pre>
:i<0/1> :inv=<yes/no>	When the invert flag is set, inverts cmask (:c<cmask> or :cmask=<cmask>) comparison, so that both greater than or equal to and less than comparisons can be made (<0>: greater than equal to comparison, <1>: less than comparison). Invert flag is ignored when :c<cmask> is programmed to 0. A value of 0 disables invert and 1 enables it.
:u<umask> :umask=<umask>	<umask> indicates the value of the event's unit mask to identify a specific microarchitectural condition. The <umask> value must be in the range 0x0 to 0xff.
:p<0/1>	When set, enables toggling of PMi pin for each event occurrence rather than during counter overflow.
:request=<request name as string>	Programming request type in the off-core response facility for a transaction request to the uncore. The request type specification must be accompanied by a response type.
:response=<response name as string>	Programming response type in the off-core response facility for a transaction request to the uncore. The response type specification must be accompanied by a request type.
:t=<threshold_num>	Threshold programming for uncore PMON_CTLx register. For events that increment more than 1 per cycle, if the threshold value is greater than 1, the data register will accumulate instances in which the event increment is >= threshold.
:rx_match=<value> :rx_mask=<value> :tx_match=<value> :tx_mask=<value>	Modifiers are all applicable to uncore Intel® QuickPath Interconnect (Intel® QPI) for programming filter registers.

Modifier	Description
:state=<value>	Applicable to uncore CHA to program state bit field of filter MSR_0.
:tid=<value>	Applicable to uncore CBO to program tid bit field of filter MSR_0.
:filter0=<value>	Applicable to CBO/CHA to program filter MSR_0.
:filter1=<value>	Applicable to CBO/CHA to program filter MSR_1.
:nc=<value>	Applicable to CBO/CHA to filter non-coherent requests by programming nc bit field of filter MSR_1.
:opc=<value>	Applicable to CBO/CHA to filter events based on their OPCODE by programming opc bit field of filter MSR_1.
:nid=<value>	Applicable to CBO/CHA to filter events by programming nid bit field of filter MSR_1.
:msr=<msr_index>	Read static and freerun event counts based on msr index provided in the command line.
:scope=<thread/ Module/package>	Set scope for power events specified through :msr event modifier. The scope needs to be one of the 3 strings from the modifier column.
:type=<static/ Freerun>	Set type of power events specified through :msr event modifier. The event type needs to be one of 2 string from the modifier column.
:ccst_debug= <hex_num>	Applicable to Power Control Unit (PCU) for programming debug MSR.
:umask_ext=<value>	Enables setting extended umask bits in the counter control register when used with applicable uncore events.

-preset-list

Presets are predefined event sets made available by the tool. This option lists all available presets.

```
-bash-4.2$ emon -preset-list
Preset[pgx] :
Platform Guided Exploration: Top-Down analysis model for all system components

Preset[pgx] :

Preset[pgx] :
Platform Guided Exploration: Top-Down analysis model for all system components
```

-preset <name>

Collect data for the given preset. To obtain available presets, use `emon -preset-list` command. Presets cannot be used along with `-C` option. When presets are used in combination with `-v` or `-s` options, EMON generates spreadsheet-friendly output.

```
-bash-4.2$ emon -preset pgx
Version Info: public V10.1.0 (Feb  1 2018 at 10:02:03) Intel(R) Processor code named S
kylake M:94 S:0

INST_RETIRED.ANY          6,624,422,544    302,153,599      19,682,258      355,635 42,721
,984      518,014 72,930 669,193 30,947
CPU_CLK_UNHALTED.REF_TSC    6,624,422,544    258,802,440      23,257,416      426,60
4 32,825,784      371,772 120,520 1,121,112      78,568
CPU_CLK_UNHALTED.THREAD_ANY  6,624,422,544    281,651,053      25,329,162      1,614,
090      35,692,101      281,648,990      25,329,107      1,614,340      35,692,104

IDQ_UOPS_NOT_DELIVERED.CORE  6,624,422,544    260,213,585      15,788,772      631,51
5 3,121,975      498,623 69,197 1,093,389      51,785
UOPS_ISSUED.ANY 6,624,422,544    399,950,753      29,862,747      516,372 58,917,536
620,665 117,935 964,720 52,487
UOPS_RETIRED.RETIRE_SLOTS    6,624,422,544    380,030,171      29,161,870      436,46
0 58,833,379      553,712 104,765 890,924 45,905
INT_MISC.RECOVERY_CYCLES_ANY  6,624,422,544    2,642,689      260,720 33,452 18,468
2,642,625      260,712 33,487 18,468
UNC_CBO_CACHE_LOOKUP.ANY_I    6,624,422,544    6,739 6,835 8,469 7,607 0

UNC_IMC_DRAM_DATA_READS 6,624,422,544    23,714
UNC_IMC_DRAM_DATA_WRITES      6,624,422,544    12,090
UNC_IMC_DRAM_GT_REQUESTS      6,624,422,544    0
UNC_IMC_DRAM_IA_REQUESTS      6,624,422,544    35,597
UNC_IMC_DRAM_IO_REQUESTS      6,624,422,544    221
-----
...
```

-t <time in sec>

Time (seconds) that an event set is monitored for. Default value is 3 s. To run EMON for the duration of application execution, use `-t0` along with an application. EMON kills the application after it finishes executing all given event sets for the specified duration when `-t0` is not specified.

The following command executes until matrix application finishes:

```
emon -t0 -C "INST_RETIRED.ANY" matrix "4 4096"
```

The following command kills the application and terminates after 10 s:

```
emon -t10 -C "INST_RETIRED.ANY" matrix "4 4096"
```

-l <loops>

The number of times each event set is monitored. Default value is 1. Event sets are interleaved.

For example, if two events sets A and B are specified and time equals 4 and loops equal 2, event set A is monitored for 4 seconds, and then event set B is monitored for 4 seconds, and then event set A is monitored for 4 seconds, and, finally, event set B is monitored for 4 seconds.

```
-bash-4.2$ emon -t4 -l2 -C "INST_RETIRED.ANY,BR_INST_RETIRED.ALL_BRANCHES"
Version Info: public V10.1.0 (Feb 1 2018 at 10:02:03) Intel(R) Processor code named S
kylake M:94 S:0

INST_RETIRED.ANY          8,832,408,718  402,554,887    319,429 1,557,350    56,881
,466    1,493  24,947,222    1,322,551    246,641
BR_INST_RETIRED.ALL_BRANCHES 8,832,408,718  98,360,811    52,483 287,100 9,662,
202    291    4,610,595    248,737 44,103
=====
INST_RETIRED.ANY          8,832,171,044  402,845,212    339,033 2,483,690    56,617
,358    1,493  25,033,773    921,139 83,362
BR_INST_RETIRED.ALL_BRANCHES 8,832,171,044  98,461,065    55,996 479,673 9,614,
240    291    4,627,796    161,736 15,905
=====
8.000s real
```

When launched with an application and the total monitoring time is less than application execution time, EMON kills the application after executing all loops. In the following example, each loop runs for 3 s for a total duration of 6 s, after which EMON would kill matrix application and exit:

```
emon -l2 -C "INST_RETIRED.ANY" matrix "16 8192"
```

When specified with an application and the total monitoring time is greater than application execution time, EMON continues executing loops in the remaining time. In the following example, each loop runs for 3 s for a total duration of 30 s while matrix application is expected to finish much sooner:

```
emon -l10 -C "INST_RETIRED.ANY" matrix "2 1024"
```

When specified with time 0 s and an application, EMON executes each loop for the duration of application execution. For example, in the following command assuming matrix application takes about 6 s to complete, each loop could run for ~6 s for a total duration of 18 s:

```
emon -t0 -l3 -C "INST_RETIRED.ANY" matrix "2 1024"
```

-L <time>

Range for random delay of the monitor interval, specified in seconds. A random delay of 0 s to <time> is introduced between each sample. When used, each monitor interval is the value of the -t switch plus the random delay between 0 and <time> milliseconds. Defaults to 0 m. This functionality will be automatically disabled if -t switch is set to 0 s.

```
-bash-4.2$ emon -t1 -l0.5 -l5 -C CPU_CLK_UNHALTED.REF_TSC
Version Info: public V10.1.0 (Feb 1 2018 at 10:02:03) Intel(R) Processor code named S
kylake M:94 S:0

CPU_CLK_UNHALTED.REF_TSC    2,208,846,728  85,338,832    151,524 478,400 10,972
,104    828,184 7,463,316    447,580 10,120
=====
CPU_CLK_UNHALTED.REF_TSC    2,208,170,252  85,321,996    129,076 1,024,236    1
0,923,988    64,492 7,502,600    847,596 5,888
=====
CPU_CLK_UNHALTED.REF_TSC    2,208,164,220  86,716,072    66,240 357,788 10,927
,392    55,568 7,531,028    373,796 5,336
=====
CPU_CLK_UNHALTED.REF_TSC    2,208,164,166  85,828,364    63,296 364,688 10,925
,736    56,304 7,487,052    353,188 5,796
=====
CPU_CLK_UNHALTED.REF_TSC    2,208,100,868  84,342,104    131,744 494,040 12,850
,928    3,681,840    10,954,900    3,626,180    9,789,352
=====
5.000s real
```

-s <delay>

One time delay in seconds before monitoring is started.

-w

Limit loops. The number of loops is limited by the application's execution time. For example, if the total monitoring time specified by the time and loop switches is greater than the actual application execution time, the collection is stopped after the application exits.

NOTE In the example below, even with `-l10`, EMON exits after first loop.

```
-bash-4.2$ emon -l10 -w -C "INST_RETIRED.ANY" matrix "1 256"
Version Info: public V10.1.0 (Feb  1 2018 at 10:02:03) Intel(R) Processor code named Skylake M:94 S:0

Elapsed time = 0.000000 seconds
INST_RETIRED.ANY      6,624,654,314    283,997,362      24,737,446      47,771,456    6
,981,403      473,692,321      403,137 960,186 6,095,116
=====
3.000s real
```

-nb | -non-blocking

Start EMON collection in the background.

-p

Start EMON in paused state. If collection is never resumed, EMON exits after monitoring interval ends. In the following example, EMON would exit after 3 s if the collection is never resumed using `emon -resume`.

```
-bash-4.2$ emon -p -C "INST_RETIRED.ANY"
Version Info: public V10.1.0 (Feb  1 2018 at 10:02:03) Intel(R) Processor code named Skylake M:94 S:0

Emon collector successfully paused.
Emon collector was started in PAUSE mode and never RESUMED
```

-osm | -os-mode

Collect data for operating system processes only.

-um | -user-mode

Collect data for user-mode processes only.

-pause

When EMON is running in non-blocking mode or in the background, use `emon -pause` to pause a running collection.

If EMON is running in the foreground, use the following steps to pause collection:

1. Open a Bash* shell, and then set up EMON run time environment by sourcing `sep_vars.sh` file in the current Bash* shell.

For example, if EMON is installed in `/opt/intel/emon`, source `/opt/intel/emon/sep_vars.sh`.

2. From the new shell, issue `emon -pause` to pause collection.

Collection ends if the total monitoring time elapses while paused.

-resume

When EMON is running in non-blocking mode or in the background, use `emon -resume` to resume a paused collection.

If EMON is running in the foreground, use the following steps to resume collection:

1. Open a Bash* shell, and then set up EMON run time environment by sourcing `sep_vars.sh` file in the current Bash* shell.

For example, if EMON is installed in `/opt/intel/emon`, source `/opt/intel/emon/sep_vars.sh`.

2. From the new shell, issue `emon -resume` to resume collection.

-stop

When EMON is running in non-blocking mode or in the background, use `emon -stop` to stop a running collection.

If EMON is running in the foreground, use the following steps to stop collection:

1. Open a Bash* shell, and then set up EMON run time environment by sourcing `sep_vars.sh` file in the current Bash* shell.

For example, if EMON is installed in `/opt/intel/emon` source `/opt/intel/emon/sep_vars.sh`.

2. From the new shell, issue `emon -stop` to stop collection.

Input/Output Options

This section lists all options related to tool input/output with examples to illustrate the behavior of certain options. The default output mode is text-based command-line output. Additionally, EMON provides options to generate text or spreadsheet output in to files.

-f <output file>

EMON output is written to `<output file>`. The `-f` switch creates a new output file.

-F <output file>

EMON output is appended to `<output file>`. If `<output file>` does not exist, it will be created.

-i <input file>

EMON command-line arguments are provided by `<input file>`. Comments are indicated with a hashtag (`#`). All text following a hashtag in an input file is ignored.

Create an input text file with desired options. Input options can be separated by spaces or new lines. Event list following `-C` can either use a new-line separator or a comma (`,`). Use a semicolon (`;`) to start a new group.

```
-q -c -t0.1 -l100000
-C (
# group 1
INST_RETIRED.ANY
CPU_CLK_UNHALTED.REF_TSC
CPU_CLK_UNHALTED.THREAD_ANY
IDQ_UOPS_NOT_DELIVERED.CORE
UOPS_ISSUED.ANY
;
# group 2
INST_RETIRED.ANY
CPU_CLK_UNHALTED.REF_TSC
CPU_CLK_UNHALTED.THREAD
UOPS_EXECUTED.THREAD
;
)
```

-q

Default text output to command line. Minimal information is output.

-V

EMON generates output in a spreadsheet-friendly format. Use `-f` or `-F` options to create spreadsheet-friendly output files.

In this mode, data is hierarchically presented (packages->devices->Specific Core/Uncore units->event counts), making it easier to observe event counts on a particular core or uncore unit.

# START OF COLLECTION					
timestamp		package0			
		core			
epoch	timestamp	CPU0		CPU1	
		INST_RETIRED.ANY	CPU_CLK_UNHALTED.REF_TSC	INST_RETIRED.ANY	CPU_CLK_UNHALTED.REF_TSC
1513339162	91383522	203404	690042	1012915	1101392
1513339162	91578992	180092	533748	70126	309016
1513339162	91539592	206355	653220	989880	890416
1513339162	91533148				
1513339162	91416858	202878	432668	1185631	935560
1513339162	91404752	216053	417924	3765	9500
1513339162	91502090	4545325	6282312	3421485	4038526

-A

Display normalized event counts across all groups and loops in quiet mode output format.

```
-bash-4.2$ emon -C "INST_RETIRED.ANY;CPU_CLK_UNHALTED.REF_TSC,BR_INST_RETIRED.ALL_BRANCHES" -A -l2
Version Info: public V10.1.0 (Feb 1 2018 at 10:02:03) Intel(R) Processor code named Skylake M:94 S:0

INST_RETIRED.ANY          26,496,917,642  1,158,248,392  91,805,388  40,546,338
                          170,800,158  140,754 48,728  2,617,788  4,646,138
CPU_CLK_UNHALTED.REF_TSC  26,496,917,642  1,001,495,072  92,137,264  3
3,349,448  130,950,224  107,272 22,264  3,483,488  3,424,240
BR_INST_RETIRED.ALL_BRANCHES 26,496,917,642  289,739,752  16,272,790  5
,148,626  29,036,688  9,358 1,392  431,610 707,630
=====
12.000s real
```

To calculate the final counts:

1. Calculate normalized count for each event across groups (i.e., add counts of all occurrences of an event across groups and divide the accumulated value by actual number of occurrences of that event in the groups).
2. Multiply normalized count by total number of scheduled groups.
3. If there is more than one loop, repeat steps 1 and 2 for each loop and add corresponding event counts from each loop.

-S

Compute-tool defined performance metrics using normalized event counts and display in a semicolon-separated, spreadsheet-friendly format. The normalized event counts are calculated from raw event counts described in `-A` option. Use `-f` or `-F` options to create spreadsheet-friendly output files.

```
emon -preset pgx -S
```

-Sr

Behaves similar to `-s` option but additionally stores and displays raw event counts in a spreadsheet-friendly format.

```
emon -preset pgx -Sr ./raw_counts_file.csv -f ./metrics_file.csv
```

-X

Spreadsheet-friendly format. The results are output in tab-separated format. This only works for single group collection.

-c

Print system time (date-time) for each time interval. It is only available in the command-line output.

```
-bash-4.2$ emon -c -l2 -C INST_RETIRED.ANY
Version Info: public V10.1.0 (Feb  1 2018 at 10:02:03) Intel(R) Processor code n
amed Skylake M:94 S:0

02/09/2018 09:54:05.252
INST_RETIRED.ANY      6,624,416,046    302,861,568      19,593,336      401,2604
2,700,189      502,934 36,546  2,907,147      119,721
=====
02/09/2018 09:54:08.252
INST_RETIRED.ANY      6,624,200,432    291,984,537      15,850,510      14,758,5
73      50,013,329      41,477 112,279 1,227,291      2,888
=====
6.000s real
```

-d

Results are printed in formatted decimal. Formatted decimal includes comma separators. Formatted decimal is the default.

-n

Print wall clock, user, and system time for each time interval. It is only available in the command-line output.

```
-bash-4.2$ emon -n -l2 -C INST_RETIRED.ANY
Version Info: public V10.1.0 (Feb 1 2018 at 10:02:03) Intel(R) Processor code n
amed Skylake M:94 S:0

INST_RETIRED.ANY      6,624,409,918  281,405,362    1,125,431    27,498,1
99      42,546,947    92,139  22,045,828    1,106,806    87,319
3.000s real
cpu 0:    0.000s user    0.000s system    2.900s idle
cpu 1:    0.000s user    0.000s system    3.000s idle
cpu 2:    0.000s user    0.000s system    2.990s idle
cpu 3:    0.020s user    0.000s system    2.980s idle
cpu 4:    0.000s user    0.000s system    3.000s idle
cpu 5:    0.000s user    0.000s system    2.990s idle
cpu 6:    0.000s user    0.000s system    3.000s idle
cpu 7:    0.000s user    0.000s system    3.000s idle
=====
INST_RETIRED.ANY      6,624,386,192  286,500,108    18,775,941    31,670,5
33      60,150,538    85,870,191    156,805,048    283,843,478    58,869,7
99
3.000s real
cpu 0:    0.010s user    0.010s system    2.680s idle
cpu 1:    0.000s user    0.000s system    2.990s idle
cpu 2:    0.000s user    0.000s system    2.990s idle
cpu 3:    0.040s user    0.000s system    2.930s idle
cpu 4:    0.010s user    0.040s system    2.960s idle
cpu 5:    0.020s user    0.040s system    2.930s idle
cpu 6:    0.030s user    0.040s system    2.870s idle
cpu 7:    0.010s user    0.030s system    2.950s idle
=====
```

-u

Results are printed in unformatted decimal. Unformatted decimal does not include comma separators.

-x

Results are printed in hex with a leading '0x'.

Collect and Process EDP Metrics

Collect and process **EDP (EMON Data Processing)** event data to generate several performance metrics that provide an overview of system performance. Since the EDP event/metric/script files are integrated into the EMON package, no additional download is necessary for this purpose. When you use the options listed in this section, EMON selects the appropriate event/metric files to collect and process data.

Option	Action
-collect-edp	Collect data for several events
-process-edp	<p>NOTE The -process-edp option is no longer supported. Please use the -process-pyedp option instead, which supports enhanced features and is much faster.</p>
-process-pyedp	Process the data collected using the -collect-edp option. The data is automatically processed by a python script included in the package. Refer to the -process-pyedp section for more information.

Usage

Here are some typical usage scenarios to collect and process EDP metrics:

- **Launch an EMON collection and an application or workload separately**

Use the following steps if you cannot have EMON launch the application for you (for e.g. application is always running or has various phases but the collection is for a shorter duration).

1. Collect and save the data to a file named `emon.dat`, run in the background if launching the workload in the same shell.

```
emon -collect-edp > emon.dat &
```

Alternatively, specify the `emon.dat` file using the `-f` option.

```
emon -collect-edp -f emon.dat &
```

2. Launch workload along with arguments.

```
<app_path_name> <app_arguments>
```

3. Stop the `emon` collection explicitly since `-collect-edp` by default runs for a long time (several loops).

```
emon -stop
```

4. Process the data with the default configuration, which works in most of the cases. Copy the template file to the current folder and use the default configuration.

```
cp <emon_install_dir>/config/edp/pyedp_config.txt .
```

5. Process data using the default `edp` configuration file (modify to customize if needed). An EMON data file with the name `emon.dat` to be present in the current folder. This step generates several `.csv/.xlsx` result files with processed metrics.

```
emon -process-pyedp ./pyedp_config.txt
```

- **Launch an EMON collection along with an application or workload**

Use the following steps for EMON to launch the application. The data collection happens until the application terminates. You do not have to stop the collection explicitly.

1. Collect and save the data to a file named `emon.dat`. The application is launched by EMON. The `-w` option makes the collection to last until the application terminates and the `-f` option is used to save the data to `emon.dat` file

```
emon -collect-edp -f emon.dat -w <app_path_with arguments>
```

If the application prints anything to console, create a script that launches the application and redirects it's output to a file. Launch the script via EMON.

```
emon -collect-edp -f emon.dat -w <app_script_path>
```

2. Process with the default configuration, which works in most of the cases. Copy the template file to the current folder.

```
cp <emon_install_dir>/config/edp/pyedp_config.txt .
```

3. Process data using the default `edp` configuration file (modify to customize if needed). An EMON data file with the name `emon.dat` to be present in the current folder. This step generates several `.csv/.xlsx` result files with processed metrics.

```
emon -process-pyedp ./pyedp_config.txt
```

-collect-edp [edp_file=<file_name>]

Collect performance data for a list of predefined events to generate EDP metrics. This option detects the hardware platform and selects the corresponding EDP events file. This option covers core and various uncore performance blocks that are required for overall system characterization. By default, EMON uses a time interval of 100 ms when collecting event data.

```
emon -collect-edp
```

Various commonly useful scenarios of collect-edp option are listed below.

Usage

- Collect EDP event performance data. Save the data to a file (`emon.dat`) in the current folder:

```
emon -collect-edp > emon.dat
```

- Specify a custom EDP event file:

```
emon -collect-edp edp_file=<edp_event_file>
```

- Launch an application/workload. Collect EDP data until the application terminates:

```
emon -collect-edp -w <application_path_and_arguments>
```

```
emon -collect-edp edp_file=<edp_event_file> -w <application_path_and_arguments>
```

- If the application/workload prints messages to the console, add the application command line to a script/batch file and redirect the output to a file (to avoid application output going into the EMON data file). Launch the script with EMON and collect EDP data until the application terminates:

```
emon -collect-edp -w <application_script>
```

```
emon -collect-edp edp_file=<edp_event_file> -w <application_script>
```

-process-edp <edp_config_file>

Notice The `-process-edp` option is no longer supported. Please use `-process-pyedp` option instead, which supports enhanced features and is much faster.

-process-pyedp <pyedp_config_file>

Process the EDP data collected with `-collect-edp` option and generate metric reports in .csv/.xlsx format.

This option requires a path to the PyEDP configuration file as an argument. The `<emon-install-dir>/config/edp` folder contains a template for a PyEDP configuration file (`pyedp_config.txt`). Copy this file to your local folder and change configuration information as needed. For most use cases, you may be able to use `pyedp_config.txt` without any modifications.

Syntax

```
emon -process-pyedp <path_to_pyedp_config_file>
```

Prerequisites

- Install Python 3.7 or later, pip, and virtualenv.
 - **Linux:** For example (Ubuntu):

```
sudo -E apt-get update;
sudo -E apt-get upgrade
sudo -E apt-get install python3
```

```
sudo -E apt-get install python3-pip
sudo -E apt-get install python3-dev
sudo -E apt-get install virtualenv
sudo -E apt-get install dos2unix
```

- **Windows:** Install Python from <https://www.python.org/downloads>. Then, install the virtualenv using the following command.

```
python -m pip install virtualenv
```

- Install the Visual C++ 14.0 or later build tools (install Microsoft Visual Studio Build Tools and choose Desktop development with C++).
- Optionally, set up python virtual environment and install the python packages listed in the next section. In this case, the python virtual environment needs to be activated before processing data with EMON - process-pyedp option.

```
1. Virtual environment setup:
   python -m venv /path/to/env
   (e.g. python -m venv ./edp-venv)
2. Activate virtual environment:
   C:\path\to\venv\script\activate (Windows)
   source /path/to/venv/bin/activate (Linux)
3. Install
   python -m pip install .
   (installs all the python dependencies)
```

- If not using python virtual environment, install the following python packages by running the command below from <EMON_INSTALL_DIR>/config/edp/pyedp folder.

```
python3 -m pip install .
(installs all the python dependencies)
```

- The above steps install all the necessary python dependencies listed below.

- accumulation-tree
- attrs
- blosc2
- colorama
- cython
- defusedxml
- dill
- jsonschema
- msgpack
- multiprocessing
- natsort
- numexpr
- numpy
- packaging
- pandas
- py-cpuinfo
- pyrsistent
- python-dateutil
- pytz
- pyudorandom
- six
- tables
- tdigest
- tqdm
- tzdata
- xlswriter

- referencing
- jsonschema-specifications
- rpds-py
- polars
- pyarrow

Python based EDP Configuration Parameters

The `pyedp_config.txt` file contains several configuration parameters that define the data processing options. Change settings to customize the processing of collected data.

Configuration Parameter	Default Value	Purpose	Additional Details
PYTHON_PATH	python3	Specify the python package to process data.	
EMON_DATA	emon.dat	Save EMON output to a file.	Change the value to specify a different file name (along with a path to the file).
METRICS	Commented out	Specify a custom file to use for metric calculation during data processing.	Uncomment and change the value to specify a custom metric file. EMON by default uses the relevant metric file for the hardware platform.
OUTPUT	summary.xlsx	Save the generated summary spreadsheet that contains performance metrics data.	
CHART_FORMAT	Commented out	Specify a custom file that lists the format for the charts to be generated in the spreadsheet.	Uncomment and change the value to specify a custom chart format file. EMON by default uses the relevant chart format file for the hardware platform.
BEGIN	Commented out	Specify the start of the sample number to process. Specify the start of the sample numbers (for example, BEGIN=1 and END=100000) to be used to process the data. Specify a sample number or a timestamp (MM/DD/YYYY HH:MM:SS).	The BEGIN values can also be the time stamps for the starting wall clock time. For example, BEGIN="08/24/2012 17:53:20.885". The BEGIN and END settings can be used to process a subset of EMON data collected.
END	Commented out	Specify the end of the sample numbers (for example, BEGIN=1 and END=100000) to be used to process the data. Specify a sample number or a timestamp (MM/DD/YYYY HH:MM:SS).	The END values can also be the time stamps for the ending wall clock time. For example, END="08/24/2012 17:53:35". The BEGIN and END settings can be used to process a subset of EMON data collected.

Configuration Parameter	Default Value	Purpose	Additional Details
VIEW	--socket-view --core-view -- thread-view --uncore-view	Generate a combination of socket/core/thread views of the metrics data. If the socket/core/thread detailed views are not required, specify --no-detail-views, which makes the data processing faster. --uncore-view (new option) - generates uncore views based on the available uncore devices for which events were collected. Separate reports per uncore device are generated.	Values for this option can be a space-separated combination of --socket-view, --core-view, and --thread-view. Add --no-detail-views to only generate summary views.
FREQUENCY	Commented out	Specify TSC frequency in MHz (e.g. 1600) to override the measured value by EMON or in case the data is not available.	
TPS	Commented out	Number of transactions per second (TPS) for throughput-mode reports.	
PERCENTILE	95	Percentile value (integer) to include in the output, this value can be changed	Comment out if percentile is not required in the output, which makes the metric processing faster.
PARALLELISM	Commented out (uses all the threads available to process the data)	Number of threads to process data in parallel. Typically it should equal to the number of logical CPUs in your processing system.	

Collection on Hybrid Platforms

Introduction to Hybrid Platforms

The Intel client architectures starting from 12th gen are based on a hybrid model with Performance Core (P-Core) and Efficiency Core (E-Core). Depending on the application, hybrid CPU architectures can distribute core usage more efficiently than non-hybrid architectures. P-Cores are designed to handle complex workloads while E-Cores are better suited for multi-threaded throughput and power-limited scenarios. At higher power envelopes, P-Cores can provide better performance than E-Cores. At lower power envelopes, E-Cores are more desirable. Each core type has different specifications and system configurations.

For these reasons, the P-Cores are preferred for

- Priority tasks
- Limited threading applications

while E-Cores are better suited for:

- Power-limited scenarios
- Background applications that can meet their QOS (Quality of Service) requirements on that performance

Supported Core Types

To collect samples using EMON on hybrid platforms, you must first identify the core types that are supported on your system. To do this, run:

```
emon -pmu-types
```

For example, this output indicates that two core types supported by EMON tool on the system: `p-core` and `e-core`

```
$ emon -pmu-types
PMU Types supported on this platform:
p-core
e-core
cbo
ncu
imc
power
```

Available Core Types

Once you have identified the core types supported by your system, find out the core types that are available. Run:

```
emon -pmu-types available
```

In this example, there are two core types available on the system: `p-core` and `e-core`

```
$ emon -pmu-types available
PMU Types available on this machine:
p-core
e-core
cbo
ncu
imc
power
```

Note that a core type supported by your system will not display in this output unless it is actually available on your system.

Core Type Specifications on Hybrid Platforms

Each core type has different specifications (such as cache, number of PerfMon counters etc) and system configurations on hybrid platforms.

To see the core type specification, run:

```
emon -v
```

This command displays the following types of information about supported core types:

Number of Processors per Core Type

```
$ emon -v
.....
total_number_of_processors ..... 22
number_of_online_processors ..... 22
number_of_processors (P-core) ..... 12
number_of_online_processors (P-core) ..... 12
number_of_processors (E-core) ..... 10
number_of_online_processors (E-core) ..... 10
.....
```

Cache Info per Core Type

```
$ emon -v
.....
Cache Info (P-core):
L1 Data Cache ..... 48KB, 12-way, 64-byte line size
                2 HW threads share this cache, No SW Init Required
L1 Code Cache ..... 64KB, 16-way, 64-byte line size
                2 HW threads share this cache, No SW Init Required
L2 Unified Cache ..... 2MB, 16-way, 64-byte lin size
                8 HW threads share this cache, No SW Init Required
64-byte Prefetching

Cache Info (E-core):
L1 Data Cache ..... 32KB, 8-way, 64-byte line size
                No SW Init Required
L1 Code Cache ..... 64KB, 8-way, 64-byte line size
                No SW Init Required
L2 Unified Cache ..... 2MB, 16-way, 64-byte line size
                8 HW threads share this cache, No SW Init Required
64-byte Prefetching
.....
```

Specs and Configurations per Core Type

```
$ emon -v
.....
Processor Features (P-core):
number_of_selectors ..... 8
number_of_var_counters ..... 8
number_of_fixed_ctrs ..... 4
Fixed Counter Events:
counter 0 ..... INST_RETIRED.ANY
counter 1 ..... CPU_CLK_UNHALTED.THREAD
counter 2 ..... CPU_CLK_UNHALTED.REF_TSC
counter 3 ..... TOPDOWN.SLOTS
number of devices ..... 1
number_of_events ..... 595
  (Thermal Throttling) (Enabled)
  (Hyper-Threading) (Enabled)
  (DCU IP Prefetching) (Enabled)
  (DCU Streamer Prefetching) (Enabled)
  (MLC AMP Prefetching) (Enabled)
  (MLC Spatial Prefetching) (Enabled)
  (MLC Streamer Prefetching) (Enabled)
  (Cores Per Package: 6)
  (Threads Per Package: 12)
  (Threads Per COre: 2)

Processor Features (E-core):
number_of_selectors ..... 8
number_of_var_counters ..... 8
number_of_fixed_ctrs ..... 3
Fixed Counter Events:
counter 0 ..... INST_RETIRED.ANY
counter 1 ..... CPU_CLK_UNHALTED.CORE
counter 2 ..... CPU_CLK_UNHALTED.REF_TSC
number of devices ..... 1
number_of_events ..... 422
  (Thermal Throttling) (Enabled)
```

```
(DCU IP Prefetching) (Enabled)
(DCU Streamer Prefetching) (Enabled)
(DCU Next Page Prefetching) (Enabled)
(MLC Streamer Prefetching) (Enabled)
(Cores Per Package: 5)
(Threads Per Package: 10)
(Threads Per Core: 1)
.....
```

The information is displayed per core type with the each PMU name, such as P-core and E-core

Mapping Core Type to Processors

EMON collects samples for perfmon events only from applicable core types. To understand the collection result, you must first understand the core type to which each processor is mapped.

```
$ emon -v
.....
OS Processor <-> Physical/Logical Mapping
-----
OS Processor      Phys.Package   Core   Logical Processor   Core Type   Module
0                 0           0       0                   P-core      2
1                 0           0       1                   P-core      2
2                 0           0       0                   P-core      3
3                 0           0       1                   P-core      3
4                 0           0       0                   P-core      4
5                 0           0       1                   P-core      4
6                 0           0       0                   P-core      5
7                 0           0       1                   P-core      5
8                 0           0       0                   P-core      6
9                 0           0       1                   P-core      6
10                0           0       0                   P-core      7
11                0           0       1                   P-core      7
12                0           0       0                   E-core      0
13                0           1       0                   E-core      0
14                0           2       0                   E-core      0
15                0           3       0                   E-core      0
16                0           0       0                   E-core      1
17                0           1       0                   E-core      1
18                0           2       0                   E-core      1
19                0           3       0                   E-core      1
20                0           0       0                   E-core      8
21                0           1       0                   E-core      8
.....
```

The output indicates that processors 0-11 are P-core and processors 12-21 are E-core.

When the counts are generated from the collection, the counts from CPU 0-11 are for P-core and the counts from CPU 12-21 are for E-core.

The `emon -v` command also provides Module ID mapping to the processor if the module exists on the system.

Event Specifications

Each core type has a different perfmon event list. These events can be defined as common events or core-type specific events depends on the number of core types that have these events.

Common Events

There are events supported in multiple core types. Those events are considered as common events and are collected on all applicable processors.

To check the list of supported events per core type for all core types, run this command:

```
emon -l [pmu name]
```

For example,

```
$ emon -l p-core
INST_RETIRED.ANY
INST_RETIRED.PREC_DIST
BR_INST_RETIRED.ALL_BRANCHES
LONGEST_LAT_CACHE.MISS
UOPS_EXECUTED.STALLS
FRONTEND_RETIRED.L2_MISS
.....

$ emon -l e-core
INST_RETIRED.ANY
MACHINE_CLEARS.PAGE_FAULT
MEM_UOPS_RETIRED.LOAD_LATENCY_GT_4
BR_INST_RETIRED.ALL_BRANCHES
LONGEST_LAT_CACHE.MISS
ICACHE.MISSES
ICACHE.ACCESESSES
.....
```

Events that are found in events lists for both core types are **common events** such as `INST_RETIRED.ANY`, `BR_INST_RETIRED.ALL_BRANCHES`, or `LONGEST_LAT_CACHE.MISS`.

Core-Type specific events

If the events are applicable only to certain core types, those events are considered as core-type specific events and are collected only on applicable core type processors.

To check the supported event list per core type for all core types, run this command:

```
emon -l [pmu name]
```

For example,

```
$ emon -l p-core
INST_RETIRED.ANY
INST_RETIRED.PREC_DIST
BR_INST_RETIRED.ALL_BRANCHES
LONGEST_LAT_CACHE.MISS
UOPS_EXECUTED.STALLS
FRONTEND_RETIRED.L2_MISS
.....

$ emon -l e-core
INST_RETIRED.ANY
MACHINE_CLEARS.PAGE_FAULT
MEM_UOPS_RETIRED.LOAD_LATENCY_GT_4
BR_INST_RETIRED.ALL_BRANCHES
LONGEST_LAT_CACHE.MISS
ICACHE.MISSES
ICACHE.ACCESESSES
.....
```

Those events which are found only in the event list for a single core type are treated as core-type specific events.

For example, the following events are exclusively `p-core` events:

- `INST_RETIRED.PREC_DIST`

- UOPS_EXECUTED.STALLS
- FRONTEND_RETIRED.L2_MISS

These events will be collected on p-core processors only.

The following events are e-core events:

- MACHINE_CLEARS_PAGE_FAULT
- MEM_UOPS_RETIRED.LOAD_LATENCY_GT_4
- ICACHE.MISSES
- ICACHE.ACCESSSES

These events are collected on e-core processors only.

Event Collection

This section describes how you collect common and core-type events.

Collect Common Events

To specify common events from the event list and collect these events using EMON, run:

```
$ emon -C <common events>

for example>
$ emon -C INST_RETIRED.ANY, LONGEST_LAT_CACHE.MISS
```

Check if the events are collected from both core type processors:

```
$ emon -C INST_RETIRED.ANY, LONGEST_LAT_CACHE.MISS
Version Info: public V11.45 (Feb 8 2024 at 21:39:04) Intel(R) microarchitecture code named
Alderlake-S M:151 S:0

INST_RETIRED.ANY      4,838,886,402  1,106,189      373,020 1,340,873      563,566
1,415,054      9,200  16,497,235      1,035,595      1,026,578      149,867 137,397,821
9,205  1,749,284 24,744  723,919 29,848  1,669,973      288,156 9,207  34,626  9,206
9,206  90,802 27,316
LONGEST_LAT_CACHE.MISS 4,838,886,402  79,617  60,924  206,556 67,284  167,139 89      106,859
364,550 117,364 16,929  329,693 97      205,587 758      53,580 2,150  105,044 11,554 25
1,999  14175      2,999  839
=====
```

Because those events are common events across both p-core and e-core, counts are collected and displayed for all processors.

Core-Type Specific events Collection

- P-core events collection

To specify p-core-specific events from the event list and collect these events using EMON, run:

```
$ emon -C <p-core events>

for example>
$ emon -C INST_RETIRED.PREC_DIST, UOPS_EXECUTED.STALLS
```

Check if the events are collected only from p-core processors:

```
$ emon -C INST_RETIRED.PREC_DIST, UOPS_EXECUTED.STALLS
Version Info: public V11.45 (Feb 8 2024 at 21:39:04) Intel(R) microarchitecture code named
Alderlake-S M:151 S:0

INST_RETIRED.PREC_DIST 4,839,017,160  748,030 311,927 661,798 199,709 1,203,121      191,867
835,574 1,866,415      16,401,613      51,965 147,576,996      31,921 1,871,506      9,206
792,389 71,142      N/A      N/A      N/A      N/A      N/A      N/A      N/A
```

```

UOPS_EXECUTED.STALLS      4,839,017,160    3,044,491    1,144,642    3,081,917    842,849
5,117,158      871,912 5,757,953    29,788,795    7,793,259    112,192 13,627,971
79,848  7,537,156  42,291  3,579,026    286,040 N/A    N/A    N/A    N/A    N/A
N/A      N/A      N/A
=====

```

According to the processor mapping from `emon -v` output, processor 0 ~ 11 are p-core and 12 ~ 21 are e-core.

Only p-core processors 0 ~ 11 display samples and not applicable core type for example e-core processors 12 ~ 21 here display N/A

- E-core events collection

To specify e-core-specific events from the event list and collect these events using EMON, run:

```

$ emon -C <e-core events>

for example>
$ emon -C ICACHE.MISSES,ICACHE.ACCESES

```

Check if the events are collected only from e-core processors:

```

$ emon -C ICACHE.MISSES,ICACHE.ACCESES
Version Info: public V11.45 (Feb 8 2024 at 21:39:04) Intel(R) microarchitecture code named Alderlake-S M:151 S:0

ICACHE.MISSES      4,838,828,820    N/A    N/A    N/A    N/A    N/A    N/A    N/A    N/A
N/A      N/A      N/A      N/A      N/A      N/A      N/A      N/A      202,043 8,004    3,179    8,196
351      13,771      332      326
ICACHE.ACCESES      4,838,828,820    N/A    N/A    N/A    N/A    N/A    N/A    N/A    N/A
N/A      N/A      N/A      N/A      N/A      N/A    N/A      929,053 37,384    15,575    39,896
3,214      57,580      2,963    3,064
=====

```

According to the processor mapping from `emon -v` output, processor 0 ~ 11 are p-core and processor 12 ~ 21 are e-core.

Only e-core processors 12 ~ 21 display samples and not applicable core type for example p-core processors 0 ~ 11 here display N/A.

Collect Combination of Common and Core-Type Specific Events

To collect a combination of common events, p-core specific events, and e-core specific events, run:

```

$ emon -C <common events, p-core events, e-core events>

for example>
$ emon -C
INST_RETIRED.ANY, LONGEST_LAT_CACHE.MISS, INST_RETIRED.PREC_DIST, UOPS_EXECUTED.STALLS, ICACHE.MISSES
, ICACHE.ACCESES

```

Check if all events are collected from appropriate processors like below:

```

$ emon -C
INST_RETIRED.ANY, LONGEST_LAT_CACHE.MISS, INST_RETIRED.PREC_DIST, UOPS_EXECUTED.STALLS, ICACHE.MISSES
, ICACHE.ACCESES
Version Info: public V11.45 (Feb 8 2024 at 21:39:04) Intel(R) microarchitecture code named Alderlake-S M:151 S:0

INST_RETIRED.ANY      4,838,712,706    1,396,384    9,206    412,857 9,206    858,794 9,214
20,170,205      918,899 1,532,879    9,207    666,507 98,113    345,820 9,207    113,560,559
60,761  2,144,426    9,206    108,957 87,373    28,499 88,063    9,207    9,206

```

LONGEST_LAT_CACHE.MISS	4,838,712,706	91,119	89	30,682	81	49,546	79	112,015
129,590_82,357_85	33,849_8,597	18,496	72	187,482	1,360	50,633	93	3,082
2,422_6432,125_16	29							
ICACHE.MISSES	4,838,712,706	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A_N/A_N/A	N/A_N/A_N/A	N/A	N/A	N/A	241,977	349	8,589	9,859
3,642_12,740_331	318							
ICACHE.ACCESSSES	4,838,712,706	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A_N/A_N/A	N/A_N/A_N/A	N/A	N/A	N/A	1,232,926		3,168	53,812
50,364_16,850_52,998	3,072_2,904							
INST_RETIRED.PREC_DIST	4,839,153,650	1,431,545		26,891	262,443	17,290	1,057,738	
17,359_18,585,280_993,051	1,645,934	14,867	1,015,421	287,674	424,396	37,194		
133,273,069	89,148_N/A_N/A_N/A	N/A_N/A	N/A_N/A					
UOPS_EXECUTED.STALLS	4,839,153,650	5,839,973	98,049	1,073,296	54,561			
4,539,116_45,642_12,137,803	26,499,792	6,501,309	68,149	3,489,674				
204,787_1,601,970_127,225	8,337,256	280,055	N/A	N/A	N/A	N/A	N/A	
N/A_N/A_N/A								
=====								

Common events display samples to all relevant core type processors, and core type specific events display samples only on applicable core type processors and display N/A on not-applicable core type processors.

For example, LONGEST_LAT_CACHE.MISS is common event which exists in both p-core and e-core, therefore, the samples are displayed on all processors.

And INST_RETIRED.PREC_DIST is p-core specific event, p-core processors are 0 ~ 11, the samples are displayed only on p-core processors 0 ~ 11, and N/A was displayed on e-core processors 12 ~ 21 which are not-applicable processors to this event.

ICACHE.MISSES is e-core event, therefore the samples are displayed only on e-core processors 12 ~ 21 while N/A was displayed on p-core processors 0 ~ 11.

Collect Combination of Common and Core-Type Specific Events in Spreadsheet Topology Format

The output for same set of events collection in Spreadsheet Topology format can be collected using "-V" option

```
$ emon -C
INST_RETIRED.ANY, LONGEST_LAT_CACHE.MISS, INST_RETIRED.PREC_DIST, UOPS_EXECUTED.STALLS, ICACHE.MISSES
, ICACHE.ACCESSSES -V
# SYSTEM INFORMATION FOLLOWS
# emon db : meteorlake
# num_packages : 1
# num_modules_per_package : 9
# num_cores_per_package : 16
# num_logic_processor_per_core : 2
# device p-core : num_events 4, num_unit 1
# device e-core : num_events 4, num_unit 1
# tsc_freq : 2188.80 MHz
# ufs_freq : N/A MHz
# END OF SYSTEM INFORMATION
# GROUPING INFORMATION FOLLOWS
# group 0 :
INST_RETIRED.ANY, LONGEST_LAT_CACHE.MISS, INST_RETIRED.PREC_DIST, UOPS_EXECUTED.STALLS, ICACHE.MISSES
, ICACHE.ACCESSSES
# END OF GROUPING INFORMATIONS
# START OF COLLECTION
timestamp;;package0;::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
;::::::::;
;;p-core;::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::;e-
core;::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::;
```


Additionally, EMON provides the RMID association and RDT allocation through these events:

- UNC_RDT_PQR_ASSOC - bit 0:9 represents RMID and bit 32:63 represents CLOS
- UNC_CAT_L2_MASK - represents L2 cache allocation capacity associated with the COS on each logical processors.
- UNC_CAT_L3_MASK - represents L3 cache allocation capacity associated with the COS on each logical processors.

For more information, see these chapters in the Intel® Software Developer Manual:

- Monitoring Resource (RMID) Association - Chapter 17.16.6
- Cache Allocation Technology Architecture - Chapter 17.17.1

RDT Support Information

To see support information for Intel RDT on your system, run:

```
emon -v
```

For example,

```
$ emon -v
.....
RDT HW Support:
  L3 Cache Occupancy      : Yes
  Total Memory Bandwidth  : Yes
  Local Memory Bandwidth  : Yes
  L3 Cache Allocation      : Yes
  L2 Cache Allocation      : No
  Highest Available RMID   : 175
  Sample Multiplier        : 90112
  Number of MBA CLOS       : 15
.....
```

Supported RDT Events

SEP determines the support for each RDT event. To see a list of these events, run:

```
emon -l rdt
```

For example,

```
$ emon -l rdt
UNC_CMT_L3_CACHE_OCCUPANCY
UNC_MBM_TOTAL_EXTERNAL_BW
UNC_MBM_LOCAL_EXTERNAL_BW
UNC_RDT_PQR_ASSOC
UNC_CAT_L2_MASK
UNC_CAT_L3_MASK
```

Collect RDT Events

To collect RDT events, run:

```
emon -C <RDT Event List>
```

For example,

```
$ emon -C <RDT Event List>

$ emon -C
UNC_CMT_L3_CACHE_OCCUPANCY,UNC_MBM_TOTAL_EXTERNAL_BW,UNC_MBM_LOCAL_EXTERNAL_BW,UNC_RDT_PQR_ASSOC,
UNC_CAT_L2_MASK,UNC_CAT_L3_MASK
```

RDT Standalone Mode

To profile cache usage by hardware core, include the `-rdt-auto-rmid` option. The EMON tool assigns the core ID for each core as the RMID.

```
$ emon -C <RDT Event List> -rdt-auto-rmid
```

Logging Options

--dump-driver-log [file_name]

Dump the contents of the sampling driver's internal log to the given file in binary format. Default file name is `driver_log.dump` if none specified.

```
emon --dump-driver-log
```

--decode-driver-log [input_file]

Decode the log buffer dump to text format. Default file to decode would be `driver_log.dump` if none is specified.

```
emon --decode-driver-log
```

--extract-driver-log <input core dump> [output file]

Identifies and extracts the most recent instance of the driver log from the specified uncompressed core dump into the output file. Default output file is `driver_log.dump` if none specified.

```
emon --extract-driver-log ./core.dump
```

Other Options

-experimental

Experimental events are those events that have not been validated in hardware. When used with `emon -1`, all available experimental events are displayed along with regular events. To list experimental along with regular events, use the following command:

```
emon -1 -experimental
```

To run collection on experimental events, use:

```
emon -C "<EVENT1,EVENT2>" -experimental
```

--per-cpu-tsc

Display timestamp counter value on each core.

```
$ emon --per-cpu-tsc -C CPU_CLK_UNHALTED.REF_TSC
Version Info: public V11.45 (Feb 8 2024 at 21:39:04) Intel(R) microarchitecture code named
Coffeelake M:158 S:10

TSC_VALUE          9,577,754,242    9,577,754,242    9,577,755,072    9,577,754,264    9,577,530,528
9,577,754,407    9,577,755,030    9,577,754,224    9,577,755,179    9,577,754,288    9,577,557,202
9,577,754,341          9,577,754,961
CPU_CLK_UNHALTED.REF_TSC          9,577,754,242    9,601,004          3,586,611          6,761,321
4,558,575          20,537,062          12,168,170          10,449,677          14,594,489          37,408,112
8,231,636  17,283,882          41,970,943
=====
3.000s real
```

--per-cpu-absolute-tsc

This option prints absolute timestamp value on each core. This feature helps to correlate with other types of data collected on the system.

```
$ emon --per-cpu-absolute-tsc -C CPU_CLK_UNHALTED.REF_TSC
Version Info: public V11.45 (Feb 8 2024 at 21:39:04) Intel(R) microarchitecture code named
Coffeelake M:158 S:10

TSC_ABSOLUTE_VALUE    5,436,596,628,262,328    5,436,596,628,262,328    5,436,596,628,262,384
5,436,596,628,262,304    5,436,596,628,061,615    5,436,596,628,262,328    5,436,596,628,263,003
5,436,596,628,262,360          5,436,596,628,262,429    5,436,596,628,262,283
5,436,596,628,036,828    5,436,596,628,262,376    5,436,596,628,262,900
CPU_CLK_UNHALTED.REF_TSC          5,436,596,628,262,328    18,724,538          46,608,520
148,557,143          49,034,174          14,900,522          8,415,309          24,188,311          5,936,854
3,759,511          443,525,607  1,960,952          25,086,460
=====
3.000s real
cpu 0:    0.000s user    0.000s system    3.000s idle
cpu 1:    0.000s user    0.000s system    2.990s idle
cpu 2:    0.030s user    0.010s system    2.960s idle
cpu 3:    0.000s user    0.000s system    2.990s idle
```

-verbose

Display EMON output in verbose mode.

3

Examples

This chapter describes the most common EMON use cases.

Basic

This is the most basic EMON command to run a collection.

```
-bash-4.2$ emon -C "CPU_CLK_UNHALTED.REF_TSC"
Version Info: public V10.1.0 (Feb  1 2018 at 10:02:03) Intel(R) Processor code n
amed Skylake M:94 S:0

CPU_CLK_UNHALTED.REF_TSC      6,624,417,122    259,372,748      465,060 1,634,10
4      32,804,440      369,840 23,364,872      1,093,144      106,996
=====
3.000s real
```

If not otherwise specified, EMON will monitor once for an interval of 3 s. To change either the interval length or the number of intervals (or loops), use the `-t` or `-l` options, respectively.

The basic command creates the data output in quiet mode, which means a minimal amount of output. To print out the headers for importing into a spreadsheet, specify the spreadsheet mode with the `-x` flag.

```
-bash-4.2$ emon -C "CPU_CLK_UNHALTED.REF_TSC" -X
Sample  Clocks  CPU_CLK_UNHALTED.REF_TSC[CPU0]  CPU_CLK_UNHALTED.REF_TSC[CPU1] C
PU_CLK_UNHALTED.REF_TSC[CPU2]    CPU_CLK_UNHALTED.REF_TSC[CPU3]  CPU_CLK_UNHALTED
.REF_TSC[CPU4]  CPU_CLK_UNHALTED.REF_TSC[CPU5]  CPU_CLK_UNHALTED.REF_TSC[CPU6] C
PU_CLK_UNHALTED.REF_TSC[CPU7]
1      6,624,180,154    250,550,132      9,470,296      1,108,968      32,837,2
84      73,784    23,350,152      961,492 425,500
```

Multi-group Core Events

Events can be broken in to multiple groups forcibly through command line or automatically scheduled in to multiple groups by the tool due to hardware counter restrictions. EMON command launches multiple groups forcibly as shown below (note the semicolon (;) instead of comma (,)):

```
-bash-4.2$ emon -C "INST_RETIRED.ANY;BR_INST_RETIRED.ALL_BRANCHES"
Version Info: public V10.1.0 (Feb  1 2018 at 10:02:03) Intel(R) Processor code n
amed Skylake M:94 S:0

INST_RETIRED.ANY      6,624,410,488    274,984,311      1,218,972      27,115,8
27      42,626,387      3,627    1,815    699,888 19,076,530
-----
BR_INST_RETIRED.ALL_BRANCHES  6,624,183,628    69,023,582      218,417 5,111,40
6      7,240,253      10,010    348    436,437 3,438,438
=====
6.000s real
```

Assuming a CPU core has four general purpose (GP) counters, the tool can program only four GP events in a single iteration of event collection. The remaining events will be moved into new groups. EMON performs multiple runs for each group. In the following example, the GP event `UOPS_ISSUED.ANY` is scheduled in a second run.

```
-bash-4.2$ emon -C "INST_RETIRED.ANY,BR_INST_RETIRED.ALL_BRANCHES,BR_MISP_RETIRED.ANY"
Version Info: public V10.1.0 (Feb 1 2018 at 10:02:03) Intel(R) Processor code named Skylake M:94 S:0

INST_RETIRED.ANY          6,624,348,660  275,121,305    1,167,297    26,096,215
                          60,070,730   34,494  43,835  1,178,225    31,843
BR_INST_RETIRED.ALL_BRANCHES 6,624,348,660  68,813,981    216,680  4,785,170
                          10,483,634    6,443   8,326  224,584  6,008
BR_MISP_RETIRED.ALL_BRANCHES 6,624,348,660  248,083  1,715    14,555  13,587  204
                          206    3,565  168
LONGEST_LAT_CACHE.REFERENCE 6,624,348,660  3,067,078    49,031  712,2611
                          ,009,419    4,398  3,739  58,458  3,247
LONGEST_LAT_CACHE.MISS 6,624,348,660  11,560  6,553  3,110  3,418  387  61
                          7,856  419
-----
UOPS_ISSUED.ANY 6,624,158,702  361,297,991    1,734,140    38,803,734  8
5,730,982    2,836  979,632  903,880  381,580
=====
6.000s real
```

Multi-group Core and Uncore Events

The number of events programmed in each group for a device depends on available counters on that device. For example, group 0 could have 4 GP events on a core, 2 GP events per CBO unit, 1 GP event per PCU unit, and so on. In the following example, the first group has 4 GP events on a core and 2 GP events on CBO. The remaining core and CBO events are scheduled in the next group.

```
-bash-4.2$ emon -C "INST_RETIRED.ANY,BR_INST_RETIRED.ALL_BRANCHES,BR_MISP_RETIRED.ANY,UNC_CBO_CACHE_LOOKUP.ANY_I,UNC_CBO_CACHE_LOOKUP.READ_I,UNC_CBO_CACHE_LOOKUP.WRITE_M"
Version Info: public V10.1.0 (Feb 1 2018 at 10:02:03) Intel(R) Processor code named Skylake M:94 S:0

INST_RETIRED.ANY          6,624,432,162  295,741,682    18,282,747    3,271,704
                          46,238,158   953,964  92,743  974,880  39,757
BR_INST_RETIRED.ALL_BRANCHES 6,624,432,162  72,528,953    3,378,739  6
51,846  7,908,147    208,829  17,303  174,088  7,506
BR_MISP_RETIRED.ALL_BRANCHES 6,624,432,162  261,837  10,035  10,416  4,218  5
,404    300    2,559  229
LONGEST_LAT_CACHE.REFERENCE 6,624,432,162  5,020,381    889,850  128,9271
27,539  59,830  6,540  67,880  4,480
LONGEST_LAT_CACHE.MISS 6,624,432,162  13,930  5,209  22,352  3,668  16,119  5
89    7,264  622
UNC_CBO_CACHE_LOOKUP.ANY_I    6,624,432,162  10,850  11,049  12,579  11,755  0
UNC_CBO_CACHE_LOOKUP.READ_I    6,624,432,162  5,036  5,120  5,131  5,070  0
-----
UOPS_ISSUED.ANY 6,624,212,894  393,014,966    29,619,745    5,888,431  5
8,725,057    77,038  347,972  1,006,431    234,066
UNC_CBO_CACHE_LOOKUP.WRITE_M 6,624,212,894  50,524  53,034  47,859  45,932  0
=====
6.000s real
```

4

Help and Troubleshoot

This chapter provides helpful tips and troubleshooting guidance.

Getting Started With EMON

To get started with EMON:

1. Identify hardware events of interest using `emon -1/-?` options.

NOTE For details on event descriptions, see Intel® Software Developer's Manual (Intel® SDM) documentation. Events mentioned in the examples in this guide may not work on all platforms since each platform has its own event lists.

2. Identify processor and memory configuration using `emon -v`.
3. Refer to the applicable sections in this document or use `emon -h` to understand the available tool options and example usages.

Discarded Events

The following situations could result in discarded events:

- An event could be discarded if it is not available on the platform. If an event is discarded due to this reason, the event will not be displayed by `emon -1`.
- An event could be discarded if the system does not come with the device types that support the event. For example, if a system does not come with FPGA units, FPGA events would be discarded.
- If it is a private event and needs special access privileges. In such a case, the event will not be displayed by `emon -1`. By using an non-disclosure agreement (NDA) release package, this problem can be resolved.

Experimental Events

Some events are available as experimental events if they are not verified in the hardware. These events are not displayed by `emon -1`. To get event list along with available experimental events use, `emon -1 -experimental` or `emon -1 -all`. To collect data on experimental events, use `emon -C -experimental`.

Deprecated Events

Certain events are marked deprecated by the tool. EMON will stop supporting deprecated events in future product releases. The tool provides replacement suggestions in place of deprecated events. To obtain a list of deprecated events, use `emon -?` and look for "deprecated" string.