



Cavium ThunderX2® CN99XX PMU Events (Abridged)

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Introduction

The ARM architecture defines several events as part of the Performance Monitor Unit (PMU) Extension. The Cavium ThunderX2 CN99XX processor implements the "required events" as documented in section D5.10.7 of the "ARM Architecture Reference Manual ARMv8, for ARMv8-A architecture profile". In addition, herein, we document those "IMPLEMENTATION DEFINED" events which Cavium deems most useful for analyzing performance.

More details for the registers and the mechanisms to access them are discussed in this document.

Counting Across Threads

The ARMv8 Debug Architecture provides a control bit (MT) in the Event Type registers to enable counting across threads for a CPU core which supports multiple hardware threads. For a first thread to count events from a second thread, both threads must be allowed to count.

Event Number	Event Type	Event Mnemonic	Description
0x0000	A	SW_INCR	Instruction architecturally executed, condition code check pass, software increment
0x0001	M	L1I_CACHE_REFILL	Level 1 instruction cache refill
0x0002	M	L1I_TLB_REFILL	Level 1 instruction TLB refill
0x0003	M	L1D_CACHE_REFILL	Level 1 data cache refill
0x0004	M	L1D_CACHE	Level 1 data cache access
0x0005	M	L1D_TLB_REFILL	Level 1 data TLB refill
0x0006	A	LD_RETIRED	Instruction architecturally executed, condition code check pass, load
0x0007	A	ST_RETIRED	Instruction architecturally executed, condition code check pass, store
0x0008	A	INST_RETIRED	Instruction architecturally executed
0x0009	A	EXC_TAKEN	Exception taken
0x000A	A	EXC_RETURN	Instruction architecturally executed, condition code check pass, exception return
0x000B	A	CID_WRITE_RETIRED	Instruction architecturally executed, condition code check pass, write to CONTEXTIDR
0x000D	A	BR_IMMED_RETIRED	Instruction architecturally executed, immediate branch
0x000E	A	BR_RETURN_RETIRED	Instruction architecturally executed, condition code check pass, procedure return
0x000F	A	UNALIGNED_LDST_RETIRED	Instruction architecturally executed, condition code check pass, unaligned load or store
0x0010	M	BR_MIS_PRED	Mispredicted or not predicted branch speculatively executed
0x0011	M	CPU_CYCLES	Cycle
0x0012	M	BR_PRED	Predictable branch speculatively executed
0x0013	M	MEM_ACCESS	Data memory access
0x0014	M	L1I_CACHE	Level 1 instruction cache access
0x0015	M	L1D_CACHE_WB	Level 1 data cache write-back

Event Number	Event Type	Event Mnemonic	Description
0x0016	M	L2D_CACHE	Level 2 data/unified cache access
0x0017	M	L2D_CACHE_REFILL	Level 2 data/unified cache refill
0x0018	M	L2D_CACHE_WB	Level 2 data/unified cache write back
0x0019	M	BUS_ACCESS	Bus access
0x001B	M	INST_SPEC	Operation speculatively executed
0x001C	A	TTBR_WRITE_RETIRED	Instruction architecturally executed, condition code check pass, write to TTBR
0x001E	A	CHAIN	For odd-numbered counters, increments the count by one for each overflow of the preceding even numbered counter.
0x001F	M	L1D_CACHE_ALLOCATE	Level 1 data cache allocation without refill
0x0020	M	L2D_CACHE_ALLOCATE	Level 2 data/unified cache allocation without refill
0x0021	A	BR_RETIRED	Counts all branches on the architecturally executed path that would incur cost if mispredicted.
0x0022	A	BR_MIS_PRED_RETIRED	Instruction executed, mispredicted branch. All instructions counted by BR RETIRED that were not correctly predicted
0x0023	M	STALL_FRONTEND	Cycle on which no operation issued because there are no operations to issue.
0x0024	M	STALL_BACKEND	Cycle on which no operation issued due to back-end resources being unavailable.
0x0025	M	L1D_TLB	Level 1 data TLB access
0x0026	M	L1I_TLB	Level 1 instruction TLB access
0x002D	M	L2D_TLB_REFILL	Attributable memory-read/write operation that causes a TLB refill of at least the Level 2 data or unified TLB
0x002E	M	L2I_TLB_REFILL	Attributable instruction memory accesses that cause a TLB refill of at least the Level 2 instruction or unified TLB.
0x002F	M	L2D_TLB	Attributable memory read/write operation that causes a TLB access to at least the Level 2 data or unified TLB.
0x0030	M	L2I_TLB	Attributable memory read/write operation that causes a TLB access to at least the Level 2 instruction or unified TLB. MMU
0x0040	M	L1D_CACHE_RD	Level 1 data cache access, read
0x0041	M	L1D_CACHE_WR	Level 1 data cache access, write
0x0042	M	L1D_CACHE_REFILL_RD	Level 1 data cache refill, read
0x0043	M	L1D_CACHE_REFILL_WR	Level 1 data cache refill, write
0x0044	M	L1D_CACHE_REFILL_INNER	Level 1 data cache refill, inner
0x0045	M	L1D_CACHE_REFILL_OUTER	Level 1 data cache refill, outer
0x0046	M	L1D_CACHE_WB_VICTIM	Level 1 data cache write-back, victim (threadless)
0x0047	M	L1D_CACHE_WB_CLEAN	Level 1 data cache write-back, cleaning and coherency (thread- less)
0x0048	M	L1D_CACHE_INVAL	Level 1 data cache invalidate (threadless)
0x004C	M	L1D_TLB_REFILL_RD	Level 1 data TLB refill, read

Event Number	Event Type	Event Mnemonic	Description
0x004D	M	L1D_TLB_REFILL_WR	Level 1 data TLB refill, write
0x004E	M	L1D_TLB_RD	Level 1 data TLB access, read
0x004F	M	L1D_TLB_WR	Level 1 data TLB access, write
0x0050	M	L2D_CACHE_RD	Level 2 data cache access, read
0x0051	M	L2D_CACHE_WR	Level 2 data cache access, write
0x0052	M	L2D_CACHE_REFILL_RD	Level 2 data cache refill, read
0x0053	M	L2D_CACHE_REFILL_WR	Level 2 data cache refill, write
0x0056	M	L2D_CACHE_WB_VICTIM	Level 2 data cache write-back, victim
0x0057	M	L2D_CACHE_WB_CLEAN	Level 2 data cache write-back, cleaning and coherency
0x0058	M	L2D_CACHE_INVALID	Level 2 data cache invalidate
0x005C	M	L2D_TLB_REFILL_RD	Level 2 data/unified TLB refill, read
0x005D	M	L2D_TLB_REFILL_WR	Level 2 data/unified TLB refill, write
0x005E	M	L2D_TLB_RD	Level 2 data/unified TLB access, read
0x005F	M	L2D_TLB_WR	Level 2 data/unified TLB access, read
0x0060	M	BUS_ACCESS_RD	Bus access, read
0x0061	M	BUS_ACCESS_WR	Bus access, write
0x0062	M	BUS_ACCESS_SHARED	Bus access, Normal, Cacheable, Shareable
0x0063	M	BUS_ACCESS_NOT_SHARED	Bus access, not Normal, Cacheable, Shareable
0x0064	M	BUS_ACCESS_NORMAL	Bus access, normal
0x0065	M	BUS_ACCESS_PERIPH	Bus access, peripheral
0x0066	M	MEM_ACCESS_RD	Data memory access, read
0x0067	M	MEM_ACCESS_WR	Data memory access, write
0x0068	M	UNALIGNED_LD_SPEC	Unaligned access, read
0x0069	M	UNALIGNED_ST_SPEC	Unaligned access, write (threadless)
0x006A	M	UNALIGNED_LDST_SPEC	Unaligned access (threadless)
0x006C	M	LDREX_SPEC	Exclusive operation speculatively executed, LDREX or LDX
0x006D	M	STREX_PASS_SPEC	Exclusive operation speculatively executed, STREX or STX pass
0x006E	M	STREX_FAIL_SPEC	Exclusive operation speculatively executed, STREX or STX fail
0x006F	M	STREX_SPEC	Exclusive operation speculatively executed, STREX or STX
0x0070	M	LD_SPEC	Operation speculatively executed, load
0x0071	M	ST_SPEC	Operation speculatively executed, store
0x0072	M	LDST_SPEC	Operation speculatively executed, load or store
0x0073	M	DP_SPEC	Operation speculatively executed, integer data-processing
0x0074	M	ASE_SPEC	Operation speculatively executed, Advanced SIMD instruction
0x0075	M	VFP_SPEC	Operation speculatively executed, floating-point instruction
0x0077	M	CRYPTO_SPEC	Operation speculatively executed, Cryptographic instruction
0x0078	M	BR_IMMED_SPEC	Branch speculatively executed, immediate branch

Event Number	Event Type	Event Mnemonic	Description
0x0079	M	BR_RETURN_SPEC	Branch speculatively executed, procedure return
0x007A	M	BR_INDIRECT_SPEC	Branch speculatively executed, indirect branch
0x007C	M	ISB_SPEC	Barrier speculatively executed, ISB
0x007D	M	DSB_SPEC	Barrier speculatively executed, DSB
0x007E	M	DMB_SPEC	Barrier speculatively executed, DMB
0x0081	A	EXC_UNDEF	Exception taken, Other synchronous
0x0082	A	EXC_SVC	Exception taken, Supervisor Call
0x0083	A	EXC_PABORT	Exception taken, Instruction Abort
0x0084	A	EXC_DABORT	Exception taken, Data Abort and SError
0x0086	A	EXC_IRQ	Exception taken, IRQ
0x0087	A	EXC_FIQ	Exception taken, FIQ
0x0088	A	EXC_SMC	Exception taken, Secure Monitor Call
0x008A	A	EXC_HVC	Exception taken, Hypervisor Call
0x008B	A	EXC_TRAP_PABORT	Exception taken, Instruction Abort not taken locally
0x008C	A	EXC_TRAP_DABORT	Exception taken, Data Abort or SError not taken locally
0x008D	A	EXC_TRAP_OTHER	Exception taken, Other traps not taken locally
0x008E	A	EXC_TRAP_IRQ	Exception taken, IRQ not taken locally
0x008F	A	EXC_TRAP_FIQ	Exception taken, FIQ not taken locally
0x0090	M	RC_LD_SPEC	Release consistency operation speculatively executed, Load Acquire
0x0091	M	RC_ST_SPEC	Release consistency operation speculatively executed, Store Release
0x00C1	M	L1D_LHS_VANOTP	A Load hit store retry. VA match against an older entry in the SRQ but the PA mismatches.
0x00C2	M	L1D_LHS_OVLAP	Load hit store retry. VA match against an older entry in the SRQ but the required load bytes are not all contained
0x00C3	M	L1D_LHS_VANOSD	Load hit store retry. VA match against an older entry in the SRQ but the associated store data has not been issued yet.
0x00C4	M	L1D_LHS_FWD	Load hit store forwarding. Load completes with data successfully forwarded from the SRQ.
0x00C6	M	L1D_BNKCFL	Bank Conflict load retry. A load that hits in the L1 retries due a bank read conflict with another higher priority port of the L1.
0x00C7	M	L1D_LSMQ_FULL	LSMQ full retry. A load misses the L1 but retries due to the LSMQ being full. Upon retry, sleep in the SCH until a fill return.
0x00C8	M	L1D_LSMQ_HIT	LSMQ hit retry. A load misses the L1 but retries due to hitting an LSMQ that already has 2 loads allocated to it.
0x00C9	M	L1D_EXPB_MISS	An external probe missed the L1.
0x00CA	M	L1D_L2EV_MISS	An L2 Evict operation missed the L1.
0x00CB	M	L1D_EXPB_HITM	An external probe hit a modified line in the L1. (threadless)
0x00CC	M	L1D_L2EV_HITM	An L2 Evict operation hit a modified line in the L1. (threadless)

Event Number	Event Type	Event Mnemonic	Description
0x00CD	M	L1D_EXPB_HIT	An external probe hit in the L1. (threadless)
0x00CE	M	L1D_L2EV_HIT	An L2 Evict operation hit in the L1. (threadless)
0x00CF	M	L1D_EXPB_RETRY	An external probe hit was retried by the LSU. (threadless)
0x00D0	M	L1D_L2EV_RETRY	An L2 Evict operation was retried by the LSU. (threadless)
0x00D1	M	L1D_ST_RMW	A read modify write store was drained and updated the L1. A RmW store is any store that updates 1, 2, or 3 bytes of a bank.
0x00D2	M	L1D_LSMQ00_LDREQ	A load has allocated LSMQ entry 0 and made a request to the SCU.
0x00D3	M	L1D_LSMQ00_LDVLD	LSMQ entry 0 was initiated by a load and is valid this cycle. (threadless)
0x00D4	M	L1D_LSMQ15_STREQ	A store has allocated LSMQ entry 15 and made a request to the SCU.
0x00D5	M	L1D_LSMQ15_STVLD	LSMQ entry 15 was initiated by a store and is valid this cycle. (threadless)
0x00D6	M	L1D_PB_FLUSH	LRQ ordering flush
0x00E0	M	BR_COND_MIS_PRED_RETIRE	Conditional branch instruction executed, but mis-predicted.
0x00E1	M	BR_IND_MIS_PRED_RETIRE	Indirect branch instruction executed, but mis-predicted.
0x00E2	M	BR_RETURN_MIS_PREDRETIRE	Return branch instruction executed, but mis-predicted.
0x00E8	M	OP_RETIRE	Uops executed.
0x00E9	M	LD_OP_RETIRE	Load uops executed.
0x00EA	M	ST_OP_RETIRE	Store uops executed.
0x00EB	M	FUSED_OP_RETIRE	Fused uops executed.
0x00F8	M	IRQ_MASK	Cumulative duration of a PSTATE.I interrupt mask set to 1.
0x00F9	M	FIQ_MASK	Cumulative duration of a PSTATE.F interrupt mask set to 1.
0x00FA	M	SERROR_MASK	Cumulative duration of a PSTATE.A interrupt mask set to 1.
0x0108	M	WFIWFE_SLEEP	Count every cycle in which the CPU is asleep due to having entered a low power mode on executing a WFI or WFE instruction.
0x0127	M	L2TLB_4K_PAGE_MISS	L2 TLB lookup miss using 4K page size
0x0128	M	L2TLB_64K_PAGE_MISS	L2 TLB lookup miss using 64K page size
0x0129	M	L2TLB_2M_PAGE_MISS	L2 TLB lookup miss using 2M page size
0x012A	M	L2TLB_512M_PAGE_MISS	L2 TLB lookup miss using 512M page size
0x0150	M	ISB_EMPTY	Number of cycles during which micro-op skid-buffer is empty.
0x0151	M	ISB_FULL	Num of cycles uop skid-buffer is backpressuring decode. (5 or more entries are occupied).

Event Number	Event Type	Event Mnemonic	Description
0x0152	M	STALL_NOTSELECTED	Number of cycles during which thread was available for dispatch but was not selected.
0x0153	M	ROB_RECYCLE	Number of cycles in which one or more valid micro-ops did not dis- patch due to ROB full.
0x0154	M	ISSQ_RECYCLE	Number of cycles in which one or more valid micro-ops did not dis- patch because the instruction issue queue is full.
0x0155	M	GPR_RECYCLE	Number of cycles in which one or more valid micro-ops did not dis- patch because GPR renamer pool is empty.
0x0156	M	FPR_RECYCLE	Number of cycles in which one or more valid micro-ops did not dis- patch because the FPR renamer pool is empty.
0x0158	M	LRQ_RECYCLE	Number of cycles in which one or more valid micro-ops did not dis- patch due to LRQ full.
0x0159	M	SRQ_RECYCLE	Number of cycles in which one or more valid micro-ops did not dis- patch due to SRQ full.
0x015B	M	BSR_RECYCLE	Number of cycles in which one or more valid micro-ops did not dis- patch because the branch check- point buffer is full.
0x0164	M	UOPSFUSED	Number of fused micro-ops dispatched.
0x020B	M	L2D_TLBI_INT	Internal mmu tlbi cacheops
0x020C	M	L2D_TLBI_EXT	External mmu tlbi cacheops
0x0218	M	L2D_HWPF_DMD_HIT	Scu ld/st requests that hit cache or msq for lines brought in by the hardware prefetcher
0x0219	M	L2D_HWPF_REQ_VAL	Scu hwpf requests into the pipeline
0x021A	M	L2D_HWPF_REQ_LD	Scu hwpf ld requests into the pipeline
0x021B	M	L2D_HWPF_REQ_MISS	Scu hwpf requests that miss
0x021C	M	L2D_HWPF_NEXT_LINE	Scu hwpf next line requests generated



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