OVP Guide to Using Processor Models

Model specific information for MIPS_ISA

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Chapter 1

Overview

This document provides the details of an OVP Fast Processor Model variant.

OVP Fast Processor Models are written in C and provide a C API for use in C based platforms. The models also provide a native interface for use in SystemC TLM2 platforms.

The models are written using the OVP VMI API that provides a Virtual Machine Interface that defines the behavior of the processor. The VMI API makes a clear line between model and simulator allowing very good optimization and world class high speed performance. Most models are provided as a binary shared object and also as source. This allows the download and use of the model binary or the use of the source to explore and modify the model.

The models are run through an extensive QA and regression testing process and most model families are validated using technology provided by the processor IP owners. There is a companion document (OVP Guide to Using Processor Models) which explains the general concepts of OVP Fast Processor Models and their use. It is downloadable from the OVPworld website documentation pages.

1.1 Description

MIPS32 Configurable Processor Model

1.2 Licensing

Usage of binary model under license governing simulator usage. Source of model available under Imperas Software License Agreement.

1.3 Limitations

If this model is not part of your installation, then it is available for download from www.OVPworld.org/MIPSuser.

1.4 Verification

Models have been validated correct as part of the MIPS Verified program and run through the MIPS AVP test programs

1.5 Features

ISA model - generic instruction set, minimal COP0 implementation

only MIPS32 Instruction set implemented

FPU implemented

DSP ASE Rev 2 implemented

Chapter 2

Configuration

2.1 Location

This model's VLNV is mips.ovpworld.org/processor/mips32_r1r5/1.0.
The model source is usually at:
$IMPERAS_HOME/ImperasLib/source/mips.ovpworld.org/processor/mips32_r1r5/1.0
The model binary is usually at:
$IMPERAS_HOME/lib/$IMPERAS_ARCH/ImperasLib/mips.ovpworld.org/processor/mips32_r1r5/1.0

2.2 GDB Path

The default GDB for this model is: $IMPERAS_HOME/lib/$IMPERAS_ARCH/gdb/mips-sde-elf-gdb.

2.3 Semi-Host Library

The default semi-host library file is mips.ovpworld.org/semihosting/mips32Newlib/1.0

2.4 Processor Endian-ness

This model can be set to either endian-ness (normally by a pin, or the ELF code).

2.5 QuantumLeap Support

This processor is qualified to run in a QuantumLeap enabled simulator.

2.6 Processor ELF code

The ELF code supported by this model is: 0x8.

Chapter 3

All Variants in this model

This model has these variants

Variant	Description
ISA	(described in this document)
M14K	
M14KcTLB	
M14KcFMM	
4KEc	
4KEm	
4KEp	
M4K	
4Kc	
4Km	
4Kp	
24Kc	
24Kf	
24KEc	
24KEf	
34Kc	
34Kf	
34Kn	
74Kc	
74Kf	
1004Kc	
1004Kf	
1074Kc	
1074Kf	
microAptivC	
microAptivP	
microAptivCF	
interAptiv	
interAptivUP	
proAptiv	

Table 3.1: All Variants in this model

Chapter 4

Bus Master Ports

This model has these bus master ports.

Name	min	max	Connect?	Description
INSTRUCTION	12	36	mandatory	
DATA	12	36	optional	

Table 4.1: Bus Master Ports

Chapter 5

Bus Slave Ports

This model has no bus slave ports.

Chapter 6

Net Ports

This model has these net ports.

Name	Type	Connect?	Description
reset	input	optional	Core reset
dint	input	optional	Debug external interrupt
hwint0	input	optional	External interrupt
hwint1	input	optional	External interrupt
hwint2	input	optional	External interrupt
hwint3	input	optional	External interrupt
hwint4	input	optional	External interrupt
hwint5	input	optional	External interrupt
nmi	input	optional	Non-maskable external interrupt
vc_run	input	optional	Set to force stop of execution on processor VPE (simulation control only)

Table 6.1: Net Ports

Chapter 7

FIFO Ports

This model has no FIFO ports.

Chapter 8

Formal Parameters

Name	Type	Description
variant	Enumeration	Processor variant
endian	Endian	Model endian
mipsHexFile	String	Load a MIPS hex file (test-mode)
IMPERAS_MIPS_AVP_OPCODES	Boolean	Enable MIPS-specific magic Pass/Fail opcodes (specific for AVP test termination)
MIPS_TRACE	Boolean	Enable MIPS-format trace output
supervisorMode	Boolean	Override whether processor implements supervisor mode
busErrors	Boolean	Override bus error exception behavior. When true, accesses of memory not defined by platform will cause bus error exceptions
fixedMMU	Boolean	Override the MMU type to fixed mapping when true (sets Config.MT=3, Config.KU/K23=2 and Config1.MMUSizeM1=0)
removeDSP	Boolean	Override the DSP-present configuration when true (sets Config3.DSPP/DSP2P=0)
removeCMP	Boolean	Override the CMP-Present configuration when true (sets Config3.CMGCR and GCR_BASE to 0)
removeFP	Boolean	Override the FP-Present configuration when true (sets Config1.FP to 0)
isISA	Boolean	Enable to specify ISA model (reset address from ELF, all coprocessors enabled)
hiddenTLBentries	Boolean	Deprecated - Instead set config1MMUSizeM1 to maximum value to improve performance
ITCNumEntries	Uns32	Specify number of ITC cells present (MT cores only)
ITCNumFIFO	Uns32	Specify number of ITC FIFO cells in reference ITC implementation (MT cores only)
MTFPU	Uns32	Enable multi-threaded FPU (1:old mttc1 behavior, 2:new mttc1 behavior)
supportDenormals	Boolean	Enable to specify that the FPU supports denormal operands and results
VPE0MaxTC	Uns32	Specifies the maximum TCs initially on VPE0
mpuRegions	Uns32	Number of regions for memory protection unit
mpuType	Uns32	Type of MPU implementation
mpuEnable	Boolean	Enable MPU2 segment control at reset
mpuSegment0	Uns32	Attributes for segment 0 in MPU2 SegmentControl_0 register
mpuSegment1	Uns32	Attributes for segment 1 in MPU2 SegmentControl_0 register
mpuSegment2	Uns32	Attributes for segment 2 in MPU2 SegmentControl_0 register

mpuSegment3	Uns32	Attributes for segment 3 in MPU2 SegmentControl_0 register
mpuSegment4	Uns32	Attributes for segment 4 in MPU2 SegmentControl_1 register
mpuSegment5	Uns32	Attributes for segment 5 in MPU2 SegmentControl_1 register
mpuSegment6	Uns32	Attributes for segment 6 in MPU2 SegmentControl_1 register
mpuSegment7	Uns32	Attributes for segment 7 in MPU2 SegmentControl_1 register
mpuSegment8	Uns32	Attributes for segment 8 in MPU2 SegmentControl_2 register
mpuSegment9	Uns32	Attributes for segment 9 in MPU2 SegmentControl_2 register
mpuSegment10	Uns32	Attributes for segment 10 in MPU2 SegmentControl_2 register
mpuSegment11	Uns32	Attributes for segment 11 in MPU2 SegmentControl_2 register
mpuSegment12	Uns32	Attributes for segment 12 in MPU2 SegmentControl_3 register
mpuSegment13	Uns32	Attributes for segment 13 in MPU2 SegmentControl_3 register
mpuSegment14	Uns32	Attributes for segment 14 in MPU2 SegmentControl_3 register
mpuSegment15	Uns32	Attributes for segment 15 in MPU2 SegmentControl_3 register
mvpconf0vpe	Uns32	Override MVPConf0.PVPE
mvpconf0tc	Uns32	Override MVPConf0.PTC
mvpconf0pcp	Boolean	Override MVPConf0.PCP
mvpconf0tcp	Boolean	Override MVPConf0.TCP
hasFDC	Uns32	Specify the size of Fast Debug Channel register block
statusFR	Boolean	Override power on value in Status.FR (Floating point register mode)
configDSP	Boolean	Override Config.DSP (data scratchpad RAM present)
configISP	Boolean	Override Config.ISP (instruction scratchpad RAM present)
configK0	Uns32	Override power on value of Config.K0 (set Kseg0 cacheability)
configKU	Uns32	Override power on value of Config.KU (set Useg cacheability)
configK23	Uns32	Override power on value of Config.K23 (set Kseg23 cacheability)
configMDU	Boolean	Override Config.MDU (iterative multiply/divide unit)
configMM	Boolean	Override Config.MM (merging mode for write)
configMT	Uns32	Override Config.MT
configSB	Boolean	Override Config.SB (simple bus transfers only)
MIPS16eASE	Boolean	Override Config1.CA (enables the MIPS16e ASE)
config1EP	Boolean	Override Config1.EP (EJTag present)
config1MMUSizeM1	Uns32	Override Config1.MMUSizeM1 (number of MMU entries-1)
config1WR	Boolean	Override Config1.WR (watchpoint registers present)
config1FP	Boolean	Override Config1.FP (FPU present)
config3BI	Boolean	Override Config3.BI
config3BP	Boolean	Override Config3.BP
config3CDMM	Boolean	Override Config3.CDMM
config3CTXTC	Boolean	Override Config3.CTXTC

config3DSPP	Boolean	Override Config3.DSPP
config3DSP2P	Boolean	Override Config3.DSP2P
config3IPLW	Uns32	Override Config3.IPLW
config3ISA	Uns32	Override Config3.ISA
config3ISAOnExc	Boolean	Override Config3.ISAOnExc
config3ITL	Boolean	Override Config3.ITL
config3MCU	Boolean	Override Config3.MCU
config3MMAR	Uns32	Override Config3.MMAR
config3RXI	Boolean	Override Config3.RXI
config3SC	Boolean	Override Config3.SC
config3ULRI	Boolean	Override Config3.ULRI
externalinterrupt	Boolean	Override Config3.VEIC (enables the use of an external interrupt controller)
vectoredinterrupt	Boolean	Override Config3.VInt (enables vectored interrupts)
config3VZ	Boolean	Override Config3.VZ
config4AE	Boolean	Override Config4.AE
config4IE	Uns32	Override Config4.IE
config4MMUConfig	Uns32	Override Config4.MMUConfig field (interpretation depends on MMUExtDef value)
config4MMUExtDef	Uns32	Override Config4.MMUExtDef
config4VTLBSizeExt	Uns32	Override Config4.VTLBSizeExt
config5EVA	Boolean	Override Config5.EVA
config5NFExists	Boolean	Override Config5.NFExists
config5MSAEn	Boolean	Override Config5.MSAEn
config6FTLBEn	Boolean	Override power on value of Config6.FTLBEn
config7DCIDX_MODE	Uns32	Override Config7.DCIDX_MODE
config7WII	Boolean	Override Config7.WII (wait IE/IXMT ignore)
fcsrABS2008	Boolean	Override FCSR.ABS2008 (ABS/NEG compliant with IEEE 754-2008)
fcsrNAN2008	Boolean	Override FCSR.NAN2008 (QNaN/SNaN encodings match IEEE 754-2008 recommendation)
firPS	Boolean	Override FIR.PS (PS floating point type implemented)
firHas2008	Boolean	Override FIR.Has2008 (one or more IEEE 754-2008 features present)
intctlIPFDC	Uns32	Override IntCtl.IPFDC
intctlIPTI	Uns32	Override IntCtl.IPTI
pridRevision	Uns32	Override PRId.Revision
srsctlHSS	Uns32	Override SRSCtl.HSS (number of shadow register sets)
ExceptionBase	Uns32	Specify the BEV Exception Base address. (use GCR_Cx_RESET_BASE on CMP processors)
UseExceptionBase	Boolean	Set to one to use ExceptionBase[29:12] as the corresponding BEV address bits
firstBEVExceptionBaseMaskBit	Uns32	Specify LSB position of GCR_Cx_RESET_EXT_BASE. BEVExceptionBaseMask field. Only used when SegCtl present
EVAReset	Boolean	Set to one to reset into non-legacy address map and BEV location. Only used when non-CMP and SegCtl present
ExceptionBaseMask	Uns32	Specify the ExceptionBaseMask value used for bits [27:firstBEVExceptionBaseMaskBit]. Only used when non-CMP and SegCtl present
ExceptionBasePA	Uns32	Bits [35:29] of the physical address for the BEV overlays. Only used when non-CMP and SegCtl present
EIC_OPTION	Uns32	Override the external interrupt controller EIC_OPTION
ISPRAM_SIZE	Uns32	Encoded size of the ISPRAM region (log2(<ISPRAM size in bytes>) - 11)
ISPRAM_BASE	Uns64	Starting physical address of the ISPRAM region

ISPRAM_ENABLE	Boolean	Set the enable bit of the ISPRAM region's tag (used to enable the ISPRAM region prior to reset)
ISPRAM_FILE	String	Load a MIPS hex file into the ISPRAM region prior to reset
DSPRAM_SIZE	Uns32	Encoded size of the DSPRAM region (log2(<DSPRAM size in bytes>) - 11)
DSPRAM_BASE	Uns64	Starting physical address of the DSPRAM region
DSPRAM_ENABLE	Boolean	Set the enable bit of the DSPRAM region's tag (used to enable the DSPRAM region prior to reset)

Table 8.1: Parameters that can be set in: CPU

Chapter 9

Execution Modes

Mode	Code
KERNEL	0
DEBUG	1
SUPERVISOR	2
USER	3

Table 9.1: Modes implemented in: CPU

Chapter 10

Exceptions

Exception	Code
Int	0
Mod	1
TLBL	2
TLBS	3
AdEL	4
AdES	5
IBE	6
DBE	7
Sys	8
Bp	9
RI	10
CpU	11
Ov	12
Tr	13
FPE	15
Impl1	16
Impl2	17
C2E	18
TLBRI	19
TLBXI	20
MDMX	22
WATCH	23
MCheck	24
Thread	25
DSPDis	26
Prot	29
CacheErr	30

Table 10.1: Exceptions implemented in: CPU

Chapter 11

Hierarchy of the model

A CPU core may be configured to instance many processors of a Symmetrical Multi Processor (SMP). A CPU core may also have sub elements within a processor, for example hardware threading blocks.
OVP processor models can be written to include SMP blocks and to have many levels of hierarchy. Some OVP CPU models may have a fixed hierarchy, and some may be configured by settings in a configuration register. Please see the register definitions of this model.
This model documentation shows the settings and hierarchy of the default settings for this model variant.

11.1 Level 1: CPU

This level in the model hierarchy has 12 commands.
This level in the model hierarchy has 5 register groups:

Group name	Registers
Core	33
FPU	34
DSP	9
COP0	22
Integration_support	1

Table 11.1: Register groups

This level in the model hierarchy has no children.

Chapter 12

Model Commands

A Processor model can implement one or more **Model Commands** available to be invoked from the simulator command line, from the OP API or from the Imperas Multiprocessor Debugger.

12.1 Level 1: CPU

12.1.1 isync

specify instruction address range for synchronous execution

Argument	Type	Description
-addresshi	Uns64	end address of synchronous execution range
-addresslo	Uns64	start address of synchronous execution range

Table 12.1: isync command arguments

12.1.2 itrace

enable or disable instruction tracing

Argument	Type	Description
-after	Uns64	apply after this many instructions
-enable	Boolean	enable instruction tracing
-instructioncount	Boolean	include the instruction number in each trace
-off	Boolean	disable instruction tracing
-on	Boolean	enable instruction tracing
-registerchange	Boolean	show registers changed by this instruction
-registers	Boolean	show registers after each trace

Table 12.2: itrace command arguments

12.1.3 mipsCOP0

query a COP0 register value using <register><select>

Argument	Type	Description
-register	Uns32	specify the COP0 register number

-select	Uns32	specify the COP0 register select

Table 12.3: mipsCOP0 command arguments

12.1.4 mipsCacheDisable

12.1.4.1 Argument description

Disables tag or full cache model

12.1.5 mipsCacheEnable

enable tag or full cache model

Argument	Type	Description
-debug	Uns32	set cache model debug flags
-full	Boolean	enable full cache model
-tag	Boolean	enable cache tag line only model

Table 12.4: mipsCacheEnable command arguments

12.1.6 mipsCacheRatio

Report current hit ratio for selected cache

Argument	Type	Description
-dcache	Boolean	report hit ratio for dcache
-icache	Boolean	report hit ratio for icache

Table 12.5: mipsCacheRatio command arguments

12.1.7 mipsCacheReport

12.1.7.1 Argument description

Report current cache statistics

12.1.8 mipsCacheReset

12.1.8.1 Argument description

reset the cache model

12.1.9 mipsCacheTrace

Control the tracing of cache accesses

Argument	Type	Description
-noartifact	Boolean	filter artifact accesses
-nocached	Boolean	filter cached accesses
-nodcache	Boolean	filter dcache accesses

-noicache	Boolean	filter icache accesses
-notrue	Boolean	filter true accesses
-nouncached	Boolean	filter uncached accesses
-off	Boolean	turn off the cache tracing
-on	Boolean	turn on the cache tracing

Table 12.6: mipsCacheTrace command arguments

12.1.10 mipsDebugFlags

Set the processor model debug flags to <value>

Argument	Type	Description
-value	Uns32	specify model debug flags

Table 12.7: mipsDebugFlags command arguments

12.1.11 mipsReadRegister

Read a processor register using <resource><offset>

Argument	Type	Description
-offset	Uns32	the processor register offset
-resource	Uns32	the processor register resource number

Table 12.8: mipsReadRegister command arguments

12.1.12 mipsWriteRegister

Write to a processor register using <resource><offset><value>

Argument	Type	Description
-offset	Uns32	the register offset number
-resource	Uns32	the register resource number
-value	Uns64	the register value to be written

Table 12.9: mipsWriteRegister command arguments

Chapter 13

Registers

13.1 Level 1: CPU

13.1.1 Core

Registers at level:1, type:CPU group:Core

Name	Bits	Initial-Hex	RW	Description
zero	32	0	r-	constant zero
at	32	0	rw	
v0	32	0	rw	
v1	32	0	rw	
a0	32	0	rw	
a1	32	0	rw	
a2	32	0	rw	
a3	32	0	rw	
t0	32	0	rw	
t1	32	0	rw	
t2	32	0	rw	
t3	32	0	rw	
t4	32	0	rw	
t5	32	0	rw	
t6	32	0	rw	
t7	32	0	rw	
s0	32	0	rw	
s1	32	0	rw	
s2	32	0	rw	
s3	32	0	rw	
s4	32	0	rw	
s5	32	0	rw	
s6	32	0	rw	
s7	32	0	rw	
t8	32	0	rw	
t9	32	0	rw	
k0	32	0	rw	
k1	32	0	rw	
gp	32	0	rw	
sp	32	0	rw	stack pointer
s8	32	0	rw	frame pointer
ra	32	0	rw	
pc	32	0	rw	program counter

Table 13.1: Registers at level 1, type:CPU group:Core

13.1.2 FPU

Registers at level:1, type:CPU group:FPU

Name	Bits	Initial-Hex	RW	Description
f0	32	0	rw	
f1	32	0	rw	
f2	32	0	rw	
f3	32	0	rw	
f4	32	0	rw	
f5	32	0	rw	
f6	32	0	rw	
f7	32	0	rw	
f8	32	0	rw	
f9	32	0	rw	
f10	32	0	rw	
f11	32	0	rw	
f12	32	0	rw	
f13	32	0	rw	
f14	32	0	rw	
f15	32	0	rw	
f16	32	0	rw	
f17	32	0	rw	
f18	32	0	rw	
f19	32	0	rw	
f20	32	0	rw	
f21	32	0	rw	
f22	32	0	rw	
f23	32	0	rw	
f24	32	0	rw	
f25	32	0	rw	
f26	32	0	rw	
f27	32	0	rw	
f28	32	0	rw	
f29	32	0	rw	
f30	32	0	rw	
f31	32	0	rw	
fsr	32	0	rw	floating point status
fir	32	0	r-	floating point information

Table 13.2: Registers at level 1, type:CPU group:FPU

13.1.3 DSP

Registers at level:1, type:CPU group:DSP

Name	Bits	Initial-Hex	RW	Description
lo	32	0	rw	
hi	32	0	rw	
lo1	32	0	rw	
hi1	32	0	rw	
lo2	32	0	rw	

hi2	32	0	rw	
lo3	32	0	rw	
hi3	32	0	rw	
dspctl	32	0	rw	DSP control

Table 13.3: Registers at level 1, type:CPU group:DSP

13.1.4 COP0

Registers at level:1, type:CPU group:COP0

Name	Bits	Initial-Hex	RW	Description
sr	32	4400004	rw	CP0 register 12/0 (status)
bad	32	0	rw	CP0 register 8/0 (badvaaddr)
cause	32	0	rw	CP0 register 13/0 (cause)
hwrena	32	0	rw	CP0 register 7/0
badvaddr	32	0	rw	CP0 register 8/0
count	32	0	rw	CP0 register 9/0
compare	32	0	rw	CP0 register 11/0
status	32	4400004	rw	CP0 register 12/0
intctl	32	e0000000	rw	CP0 register 12/1
srsctl	32	0	rw	CP0 register 12/2
srsmap	32	0	rw	CP0 register 12/3
epc	32	0	rw	CP0 register 14/0
prid	32	0	rw	CP0 register 15/0
ebase	32	80000000	rw	CP0 register 15/1
config	32	80008402	rw	CP0 register 16/0
config1	32	80000003	rw	CP0 register 16/1
config2	32	80000000	rw	CP0 register 16/2
config3	32	c00	rw	CP0 register 16/3
debug	32	0	rw	CP0 register 23/0
depc	32	0	rw	CP0 register 24/0
errorepc	32	0	rw	CP0 register 30/0
desave	32	0	rw	CP0 register 31/0

Table 13.4: Registers at level 1, type:CPU group:COP0

13.1.5 Integration_support

Registers at level:1, type:CPU group:Integration_support

Name	Bits	Initial-Hex	RW	Description
stop	32	0	rw	write with non-zero to stop processor

Table 13.5: Registers at level 1, type:CPU group:Integration_support