Ncore Error Architecture Specification

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ARTERIS® NCORE ERROR ARCHITECTURE SPECIFICATION

Release Information

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Legend:	MK MF CCW Xx	Mohammed Michael Frank Cheng Chung Wang Whoever else edited this document	

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Product Status

The information in this document is ***Preliminary***.

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Preface

This preface introduces the Arteris® Network-on-Chip Hierarchical Coherency Engine Architecture Specification.

About this document

This technical document is for the Arteris Network-on-Chip Hierarchical Coherency Engine Architecture. It describes the subsystems and their function along with the system's interactions with the external subsystems. It also provides reference documentation and contains programming details for registers.

Product revision status

TBD

Intended audience

This manual is for system designers, system integrators, and programmers who are designing or programming a System-on-Chip (SoC) that uses or intend to use the Arteris Network-on-Chip Hierarchical Coherency System (ANoC-HCS).

Using this document

TBD

Glossary

The Arteris© Glossary is a list of terms used in Arteris© documentation, together with definitions for those terms. The Arteris© Glossary does not contain terms that are industry standard unless the Arteris© meaning differs from the generally accepted meaning.

Typographic conventions

italic

Introduces special terminology, denotes cross-references, and citations.

bold

Highlights interface elements, such as menu names. Denotes signal names. Also used for terms in descriptive lists, where appropriate.

monospace

Denotes text that you can enter at the keyboard, such as commands, file and program names, and source code.

monospace italic

Denotes a permitted abbreviation for a command or option. You can enter the underlined text instead of the full command or option name. monospace italic Denotes arguments to monospace text where the argument is to be replaced by a specific value. monospace bold Denotes language keywords when used outside example code.

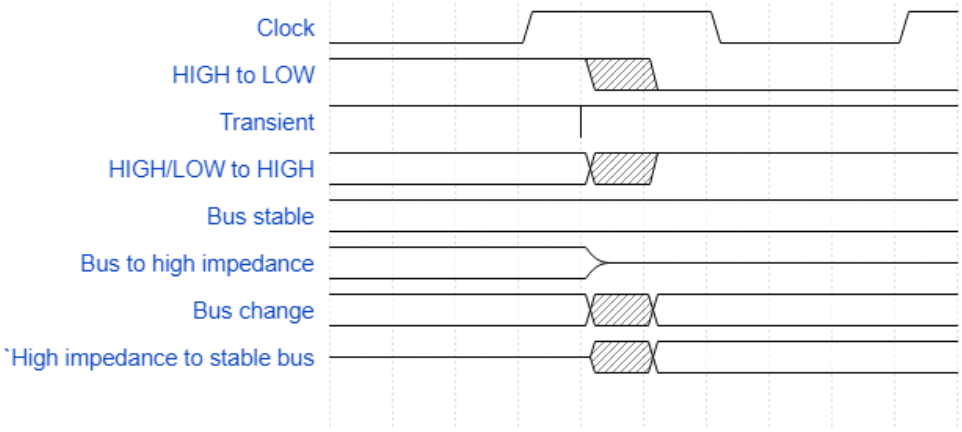
SMALL CAPITALS

Used in body text for a few terms that have specific technical meanings, that are defined in the Arteris® Glossary. For example, IMPLEMENTATION DEFINED, IMPLEMENTATION SPECIFIC, UNKNOWN, and UNPREDICTABLE.

Timing diagrams

The following figure explains the components used in timing diagrams. Variations, when they occur, have clear labels. You must not assume any timing information that is not explicit in the diagrams.

Shaded bus and signal areas are undefined, so the bus or signal can assume any value within the shaded area at that time. The actual level is unimportant and does not affect normal operation.



Signals

The signal conventions are:

Signal level

The level of an asserted signal depends on whether the signal is active-HIGH or active-LOW. Asserted means:

- HIGH for active-HIGH signals.
- LOW for active-LOW signals.

Lowercase n

At the start or end of a signal name denotes an active-LOW signal.

Additional reading

This book contains information that is specific to this product. See the following documents for other relevant information.

History of the World II, Mel Brooks.

1 Introduction

This specification goes over Error handling in Ncore. This spec is derived from the current implementation of Ncore 3.0 which was partially derived from Ncore 2.x. Effort has been made to reduce the number of changes from current implementation. In a later version of Ncore more changes and improvements will be introduced. The document first describes different registers and encodings and then goes into details of how these errors are handled.

1.1 Parameters

No new parameters introduced.

1.2 Error registers

Refer to CSR CPRs in in the hw-ncr repository under cpr/csr for register addresses.

1.2.1 Correctable Error Registers

1.2.1.1 Correctable Error Control Register (xCECR)

Register Description: This register controls the detection and interrupt signaling of Correctable Errors in the unit.

Register Fields:

Bits	Name	Access	Reset	Description
0	ErrDetEn	RW	0b0	Correctable Error Detection Enable. When set to 1, this bit enables detection and logging of correctable errors.
1	ErrIntEn	RW	0b0	Correctable Error Interrupt Enable. When set to 1, this bit enables the assertion of Correctable Error Interrupt signal when a new Correctable Error is detected and ErrCount value equals to ErrThreshold.
3:2	Reserved	-	-	-
11:4	ErrThreshold	RW	0x00	Correctable Error Threshold. Number of corrected errors for which logging, and interrupt (if ErrIntEn is set to 1) is suppressed.
31:12	Reserved	-	-	-

1.2.1.2 Correctable Error Status Register (xCESR)

Register Description: This register logs information of Correctable Errors in the unit. If a new Correctable Error attempts to log this register the same cycle xCESAR is configured, this register will contain information from xCESAR.

Register Fields:

Bits	Name	Access	Reset	Description
0	ErrVld	W1C	0b0	Correctable Error Valid. This bit is set when a Correctable Error is detected and ErrCount equals to ErrThreshold. xCESR, xCELR0 and xCELR1 contain logged information about this Correctable Error. Write 1 to the field resets it to 0b0.
1	ErrCountOverflow	RO	0b0	Correctable Error Count Overflow. This bit is set to 1 when ErrVld is asserted, and a new Correctable Error is detected. Once the field is set, it will keep asserted until being reset. The field is reset to 0b0 when ErrVld is reset.
9:2	ErrCount	RO	0x00	Correctable Error Count. This field increments when a Correctable Error is detected. Once the field reaches ErrThreshold, the value will be frozen from that time until being reset. The field is reset to 0x00 when ErrVld is reset. If write 1 to ErrVld and a new Correctable Error is detected at the same cycle, the field will not increment for the error.
11:10	Reserved	-	-	-
15:12	ErrType	RO	0x00	Correctable Error Type. When ErrVld is set to 1, the field indicates the type of error that has been detected and logged.
31:16	ErrInfo	RO	0x0000	Correctable Error Information. When ErrVld is set to 1, the field contains additional unit-specific and error-type-specific information about the error. For example, information that could help identify the site of the error.

1.2.1.3 Correctable Error Location Register (xCELR0)

Register Description: This register logs location information of Correctable Errors in the unit. The information is unit-specific (see Error Type and Information Summary). The fields are made RW accessible to utilize this register as the alias register for error information injection purpose.

Register Fields:

Bits	Name	Access	Reset	Description
31:0	ErrAddress	RW	0x0	Error Address information. When ErrVld is set to 1, the field contains location information of the error. Depending on the type of the error, the register is interpreted in different way. If error is reported from a memory or buffer array: Error Entry = bit [19:0], and [31:20] are reserved If error is reported from a Set/Way associative cache: Error Set = bit[19:0] Error Way = bit[25:20] Error Word = bit[31:26] If error is reported as the physical address of the transaction or message: Error Address = bit[31:0] (lower 32 bits, upper bits are reported in xCELR1)

1.2.1.4 Correctable Error Location Register (xCELR1)

Register Description: This register logs extra address information that cannot fit in xCELR0. The fields are made RW accessible to utilize this register as the alias register for error information injection purpose.

Register Fields:

Bits	Name	Access	Reset	Description
19:0	ErrAddr	RW	0x000	Error Address Higher Bits. Contains higher bits of error address if xELR0 cannot fit the whole error address.
31:20	Reserved	-	-	-

1.2.1.5 Correctable Error Status Alias Register (xCESAR)

Register Description: This register is used to inject error status into xCESR. If a new Correctable Error attempts to log the same cycle this register is configured, the information in this register will be logged in the xCESR.

Register Fields:

Bits	Name	Access	Reset	Description
0	ErrVld	RW	0b0	Alias bit for setting ErrVld in xCESR.
1	ErrCountOverflow	RW	0b0	Alias bit for setting ErrCountOverflow in xCESR.
9:2	ErrCount	RW	0x00	Alias field for setting ErrCount in xCESR.
11:10	Reserved	-	-	-
15:12	ErrType	RW	0x00	Alias field for setting ErrType in xCESR.
31:16	ErrInfo	RW	0x0000	Alias field for setting ErrInfo in xCESR.

1.2.1.6 Correctable Resiliency Threshold Register (xCRTR)

Register Description: This register contains the resiliency correctable error threshold as an indication to the functional safety controller (FSC). Exists only if the unit enables resiliency.

Register Fields:

Bits	Name	Access	Reset	Description
7:0	ResThreshold	RW	0x01	Resiliency Correctable Error Threshold. See FSC documents for more information.
31:8	Reserved	-	-	-

1.2.2 Uncorrectable Error Registers

1.2.2.1 Uncorrectable Error Detect Register (xUEDR)

Register Description: This register enables the detection of Uncorrectable Errors.

Bits	Name	Access	Reset	Description
0	ProtErrDetEn	RW	0b0	Protocol Error Detection Enable. When set to 1, this bit enables the detection and logging of Protocol type Uncorrectable Error.
1	TransErrDetEn	RW	0b0	Transport Error Detection Enable. When set to 1, this bit enables the detection and logging of Transport type Uncorrectable Error.
2	MemErrDetEn	RW	0b0	Memory Error Detection Enable. When set to 1, this bit enables the detection and logging of Memory type Uncorrectable Error. This field exists only when there are protected memory arrays in the unit.
3	DecErrDetEn	RW	0b0	Decode Error Detection Enable. When set to 1, this bit enables the detection and logging of Access type Uncorrectable Error.
4	TimeOutErrDetEn	RW	0b0	Time Out Error Detection Enable. When set to 1, this bit enables the detection and logging of Time Out Error.
5	SoftwareProgConfigErrDetEn	RW	0b0	Software Programming or Configuration Error Enable. When set to 1, this bit enables the detection and logging of Software Programming or Configuration Error.
6	IntfCheckErrDetEn	RW	0b0	Interface Checker Error Detection Enable. When set to 1, this bit enables the detection and logging of Interface Checker Error.
31:7	Reserved	-	-	-

1.2.2.2 Uncorrectable Error Interrupt Register (xUEIR)

Register Description: This register enables the interrupt signaling of Uncorrectable Errors.

Bits	Name	Access	Reset	Description
0	ProtErrIntEn	RW	0b0	Protocol Error Interrupt Enable. When set to 1, this bit enables the assertion of Protocol type Uncorrectable Error Interrupt signal.
1	TransErrIntEn	RW	0b0	Transport Error Interrupt Enable. When set to 1, this bit enables the assertion of Transport type Uncorrectable Error Interrupt signal.
2	MemErrIntEn	RW	0b0	Memory Error Interrupt Enable. When set to 1, this bit enables the assertion of Memory type Uncorrectable Error Interrupt signal. This field exists only when there are protected memory arrays in the unit.
3	DecErrIntEn	RW	0b0	Decode Error Interrupt Enable. When set to 1, this bit enables the assertion of Access type Uncorrectable Error Interrupt signal.
4	TimeOutErrIntEn	RW	0b0	Time Out Error Interrupt Enable. When set to 1, this bit enables the assertion of Time Out Error Interrupt signal.
5	SoftwareProgConfigErrIntEn	RW	0b0	Software Programming or Configuration Error Interrupt Enable. When set to 1, this bit enables the assertion of Software Programming or Configuration Error Interrupt signal.
6	IntfCheckErrIntEn	RW	0b0	Interface Checker Error Interrupt Enable. When set to 1, this bit enables the assertion of Interface Checker Error Interrupt signal.
31:7	Reserved	-	-	-

1.2.2.3 Uncorrectable Error Status Register (xUESR)

Register Description: This register logs information about Uncorrectable errors in the unit. If a new Uncorrectable Error attempts to log this register the same cycle xUESAR is configured, this register will contain information from xUESAR.

Register Fields:

Bits	Name	Access	Reset	Description
0	ErrVld	W1C	0b0	Uncorrectable Error Valid. This bit is set when an Uncorrectable Error is detected. xUESR, xUELR0 and xUELR1 contain logged information about this Uncorrectable Error. Write 1 to the field resets it to 0b0. If write 1 to the field and a new Uncorrectable Error is detected at the same cycle, the field is cleared.
3:1	Reserved	-	--	-
7:4	ErrType	RO	0x00	Uncorrectable Error Type. When ErrVld is set to 1, the field indicates the type of error that has been detected and logged.
11:8	Reserved	-	-	-
31:12	ErrInfo	RO	0x0000	Uncorrectable Error Information. When ErrVld is set to 1, the field contains additional unit-specific and error-type-specific information about the error. For example, information that could help identify the site of the error.

1.2.2.4 Uncorrectable Error Location Register (xUELR0)

Register Description: This register logs location information of Uncorrectable Errors in the unit. The information is unit-specific (see Error Type and Information Summary). The fields are made RW accessible to utilize this register as the alias register for error information injection purpose.

Register Fields: see Correctable Error Location Register (xCELR0)

1.2.2.5 Uncorrectable Error Location Register (xUELR1)

Register Description: This register logs extra address information that cannot fit in xUELR0. The fields are made RW accessible to utilize this register as the alias register for error information injection purpose.

Register Fields: see Correctable Error Location Register (xCELR1)

1.2.2.6 Uncorrectable Error Status Alias Register (xUESAR)

Register Description: This register is used to inject error status into xUESR. If a new Uncorrectable Error attempts to log the same cycle this register is configured, the information in this register will be logged in the xUESR.

Register Fields:

Bits	Name	Access	Reset	Description
0	ErrVld	RW	0b0	Alias bit for setting ErrVld in xUESR.
3:1	Reserved	-	-	-
7:4	ErrType	RW	0x00	Alias field for setting ErrType in xUESR.
11:8	Reserved	-	-	-
31:12	ErrInfo	RW	0x0000	Alias field for setting ErrInfo in xUESR.

1.2.3 Error Type and Information Summary

1.2.3.1 Correctable ErrorType and Info Table

ErrType Code	Error Type and ErrInfo Code (16 bits)	Error Location
0x0	Data Correctable Error • [2:0] – Storage Type ○ 3'b000 – OTT-Data ○ 3'b001 – Read Buffer ○ 3'b010 – Write Buffer ○ 3'b011 – Snoop Filter ○ 3'b100 – Trace Buffer • [7:3] – Reserved • [15:8] – Snoop Filter ID (Set field to zero for non-snoop filter)	OTT/Read Buffer/Write Buffer/Trace Buffer : Entry Snoop Filter: Set/Way
0x1	Cache Correctable Error • [0] – Array Type ○ 1'b0 - Tag Array ○ 1'b1 - Data Array • [15:1] – Reserved (set to zero)	Word/Way/Set
0x2 – 0x7	Reserved	N/A
0x8	Transport Error • [5:0] – Reserved (set to zero) • [15:6] – Source ID (FUnit_Id)	N/A No address associated with packet
0x9 – 0xF	Reserved	N/A

*MBZ: Must Be Zero

1.2.3.2 Uncorrectable ErrorType and Info Table

ErrType Code	Error Type and ErrInfo Code (20 bits)	Error Location
0x0	Data Uncorrectable Error (applies to data and memory address errors) • [2:0] – Storage Type ○ 3'b000 – OTT-Data ○ 3'b001 – Read Buffer ○ 3'b010 – Write Buffer ○ 3'b011 – Snoop Filter ○ 3'b100 – Trace Buffer • [7:3] – Reserved (set to zero) • [19:8] – Snoop Filter ID (Set field to zero for non-snoop filter)	OTT/Read Buffer/Write Buffer/Trace Buffer : Entry Snoop Filter: Set/Way
0x1	Cache Uncorrectable Error (applies to tag/data SRAM and memory address errors) • [0] – Array Type ○ 1'b0 - Tag Array ○ 1'b1 - Data Array	Word/Way/Set

ErrType Code	Error Type and ErrInfo Code (20 bits)	Error Location
0x2	Native Interface Write Response/Write Data Error • [1:0] - Response • [2] - Security Attribute • [3]- Eviction • [7:4] - Reserved (set to zero) • [19:8] – AxID/CHI TxID[1]	Transaction Address
0x3	Native Interface Read Response Error • [1:0] - Response • [2] - Security Attribute • [3]- Fill • [7:4] - Reserved • [19:8] – AxID	Transaction Address
0x4	Native Interface Snoop Response Error • [1:0] – Response • [2] - Security Attribute • [7:3] - Reserved (set to zero) • [19:8] – CHI TxID[1] (Transaction ID has 12 bits)	Transaction Address
0x5-0x6	Reserved	N/A
0x7	Decode Error • [3:0] – Type ○ 4'b0000: No address hit ○ 4'b0001: Multiple address hit ○ 4'b0010: Illegal CSR access format ○ 4'b0011: Illegal DII access type ○ 4'b0100: Illegal security access ○ 4'b0101 to 4'b1111: Reserved • [5:4] – Command Type ○ 2'b00: Read ○ 2'b01: Write ○ 2'b1x: Not used, reserved • [7:6] - Reserved (set to zero) • [19:8] – Transaction ID/AxID[1]	Transaction Address
0x8	Transport Error • [0] – Type ○ 1'b0: Wrong Target Id ○ 1'b1: SMI Protection • [7:1] – Reserved (set to zero) • [19:8] – Source ID (FUnit_Id)	N/A No address associated with packet
0x9	Timeout Error • [1:0] – command type ○ 2'b00: Reads ○ 2'b01: Writes ○ 2'b10: CMO/Dataless ○ 2'b11: DVM • [2] – Security Attribute • [7:3] – Reserved (set to zero) • [19:8] – Transaction ID/AxID[1]	Transaction Address

ErrType Code	Error Type and ErrInfo Code (20 bits)	Error Location
0xA	Sys Event Error • [0] – Type ○ 1'b0: Time out error on message (protocol timeout) ○ 1'b1: Time out error on interface • [19:1] – Reserved (set to zero)	NA
0xB	SysCo Error • [0] – Type ○ 1'b0: Time out error on message (protocol timeout) ○ 1'b1: External error reported by system response • [19:1] – Reserved (set to zero)	NA
0xC	Software Programming or Configuration Error • [3:0] – Type ○ 4'b0000: Atomic Transaction w/o CCP Only reported by DMI when atomics enabled without cache present ○ 4'b0001: No credits configured for access ○ 4'b0010: unconnected DMI unit access ○ 4'b0011: unconnected DII unit access ○ 4'b0101: unconnected DCE unit access ○ 4'b0110-4'b1111: Reserved • [19:4] – Reserved (set to zero)	Transaction Address
0xD	Interface Checker Error • [3:0] – Interface Channels ○ 4'b0xxx: Reserved for AXI/ACE Error Encodings ○ 4'b1000: CHI REQ Channel ○ 4'b1001: CHI RSP Channel ○ 4'b1010: CHI WDAT Channel ○ 4'b1011: CHI RDAT Channel ○ 4'b1100: CHI SNP Channel ○ 4'b1101: CHI SRSP Channel ○ 4'b1110: CHI SYSCO Channel ○ 4'b1111: CHI Common Channel • [19:4] – Reserved (set to zero)	NA
0xE	Unsupported Message Error • [6:0] – opcode of the transaction ○ CHI: opcode[6:0] ○ AXI/ACE/ACE-Lite: {AxLOCK[0],AxBAR[0],AxSNOOP[3:0]} • [7] – Reserved (set to zero) • [19:8] – AxID/CHI TxID[1]	Transaction Address (if applicable)
0xF	Reserved	N/A

Note:
1. CHI Transaction ID or AxID where applicable, otherwise set field to zero
2. All reserved fields shall be set to zero

1.3 Native Interface Error Response Logging and Interrupt

Uncorrectable Error is logged when an error response is detected at the native interfaces if ProtErrDetEn = 1.

- DMI/DII logs all AXI Bresp/Rresp errors
  - Bresp error => ErrorType Code 0x2 with errorinfo and location
  - Rresp error => ErrorType Code 0x3 with errorinfo and location
- CHIAIU logs all CHI data/non-data response errors
  - WriteData/WriteDataCancel/NCBWriteDataCompAck with Data Error => ErrorType Code 0x2 with errorinfo and location
  - SnpRespData with Data Error => ErrorType Code 0x4 with errorinfo and location
  - SnpResp with Non-Data Error => ErrorType Code 0x4 with errorinfo and location
- IOAIU logs all ACE CRresp errors (CRresp[1] is logged into ErrInfo Response field)
  - CRresp error => ErrorType Code 0x4 with errorinfo and location

An Uncorrectable interrupt is raised if ProtErrIntEn = 1.

CCMP must be completed with error CmStatus for DtwReq/DtwMrgMrdReq and DtrReq, if the first beat of data contains error else the CmStatus does not indicate an error. If following beats of data contain error, it is indicated by setting the appropriate DBad of the data beat. Native interface to CmStatus mapping is shown in Table 1.

Native interface	Native interface error	CmStatus	Description
AXI (DMI/DII)	SLVERR	0b10000011	Data error in CmStatus. As per ARM spec this error is reported when the slave cannot provide data due to various reasons
	DECERR	0b10000100	Address error in CmStatus. As per ARM Spec this error is reported when the slave cannot be found by the network
CHI (CAIU)	Data Error	0b10000011	Data error in CmStatus. As per ARM spec this error is reported when data is corrupted. The error may be reported on datflit or rspflit.
	Non-Date Error	0b10000100	Address error in CmStatus. As per ARM Spec this error is reported when the response cannot be completed due to various reasons. The error may be reported on datflit or rspflit.
ACE (CAIU)	CRRESP[1:0] = 10 error without data transfer	0b10000100	Address error in CmStatus. As per ARM spec, the agent cannot complete the snoop request. (Today RTL issues Target Signaled error for DVM snoops, this needs to be updated in later versions to address error) Concerto expects following: If the originating snoop was an invalidating type, then the agent is expected to go to invalid state else stay in the same state. Snoop filer is updated accordingly.
	CRRESP[1:0] = 11 error with data transfer	0b10000011	AIU should forward data error in Dtr/Dtw/DtwMrgMrd And return normal in SnpRsp

TABLE 1: NATIVE INTERFACE TO CMSTATUS MAPPING

In the cases where the data is provided at the native interface the error is propagated only on DtwReq or DtrReq. When data is not provided then the error is propagated only on SnpRsp or DtwRsp.

- DMI/DII propagate AXI response with error
  - Bresp error => DtwRsp with error status from Table 1
  - Rresp error => DtrReq with error status from Table 1
- CHIAIU propagate CHI Snoop response/WriteData with error
  - WriteData/WriteDataCancel/NCBWriteDataCompAck with Data Error => DtwReq with Data Error
  - SnpRespData with Data Error => Dtw/DtwMrgMrd/DtrReq with Data Error
  - SnpResp with Non-Data Error => SnpRsp with Address Error
- IOAIU propagate ACE snoop response with error
  - CRresp[1:0] == 10(error without data transfer) => SnpRsp with Address Error
  - CRresp[1:0] == 11(error with data transfer) => Dtw/DtwMrgMrd/DtrReq with Data Error

In Ncore System, data can be rotated per DW (Double Word), the beat data error information from native interface is carried in each DW, and after rotation, certain error type can overwrite the others. For example, in AXI, if the first beat sent on SMI contains double word for both SLVERR and DECERR, Address Error is injected into CMStatus.

CmStatus to native interface mapping is shown in Table 2. In the case of DtrReq the first beat CmStatus may not indicate error, but consecutive beats may indicate DBad in this case the consecutive beats are treated as Data Error.

- CHIAIU propagate DtrReq/DtwRsp/StrReq/CmpRsp with error if response to native interface is required
  - DtrReq => CompData with error status from Table 2
  - DtwRsp => Comp with error status from Table 2
  - StrReq => Comp/CompData with error status from Table 2
  - CmpRsp => Comp with error status from Table 2
- IOAIU propagate DtrReq/DtwRsp/StrReq/CmpRsp with error if response to native interface is required
  - DtrReq => Rresp with error status from Table 2
  - DtwRsp => Bresp with error status from Table 2
  - StrReq => B/Rresp with error status from Table 2
  - CmpRsp => Rresp with SLVERR (DVMs)

AIUs receive error from DtrReq/DtwRsp/StrReq/CmpRsp, when the native protocol is ACE in addition to the error field in RResp[1:0], RResp[3:2] includes the cache line status field. The cache line status field shall not be affected by CmStatus information. The other fields of the response are mapped to the native interface as defined when the CmStatus is not reporting error.

Native interface	CmStatus	Native interface error	Description
AXI/ACE-Lite/Ace-Lite E/ACE (NCAIU/CAIU)	0b10000011	SLVERR	Data error is best represented by SLVERR
	0b10000100	DECERR	Address error where the slave cannot be found is best represented by DECERR. In the case of DVMs (CmpRsp) this must be decoded to SLVERR
CHI (CAIU)	0b10000011	Data Error	Data error, this includes SLVERR (reported by DMI/DII) is best mapped to Data Error on CHI as Ncore does not have enough information to decode the SLVERR and it may be reported due to bad data
	0b10000100	Non-Data Error	Address error, this includes DECERR (reported by DMI/DII) is best mapped to Non-Data Error on CHI as this error is reported when the final target cannot be found.

TABLE 2 CMSTATUS TO NATIVE INTERFACE MAPPING

1.4 Transport Error Logging and Interrupt

Ncore 3 units support Wrong Target ID and SMI Protection Error.
if TransErrDetEn = 1:

- Wrong Target ID Error is logged when seeing message targetID (exclude Port_ID) mismatches unit's FUnit_ID.
- SMI Protection Error includes: Concerto Header Error, Concerto Message Error and Concerto Data Error.

Upon any of the error above happened, the message is dropped. ErrorType Code 0x8 with errorinfo and location is logged.

An Uncorrectable interrupt is raised if TransErrIntEn = 1.

Ncore units also record and report correctable transport error if ECC single bit error is detected.

1.5 Resiliency Related Error Logging and Interrupt

Please see the resiliency section for FSC(functional safety checker/controller) spec for more information.
A selected list of uncorrectable errors from a Ncore unit are reported to the fault checker in resiliency mode and will trigger mission faults.
The detailed full list of errors are listed in each uArchitecture spec of each Ncore unit.
The following two tables help to summarize the current behavior regarding each unit's error types and its ability to generate a mission fault while in resiliency mode. Logged/Detected indicates the ability of the unit to detect and log error information for that type of error. Generates Interrupt indicates the ability of the unit to generate an interrupt for that error if enabled. The last column indicates that a mission fault will be generated by the fault checker which feeds the FSC module.

Uncorrectable Error Type	Logged/Detected	Generates Interrupt	Generates Mission Fault with Resiliency
IOAIU			
Data OTT Error	Yes	Yes	Yes
Cache Tag/Data Error	Yes	Yes	Yes
Native Intf Write Resp Write Data Error	No	No	No
Native Intf Read Resp Error	No	No	No
Native Intf Snoop Resp Error	Yes	Yes	No
Decode Error	Yes	Yes	No
Transport TargID Error	Yes	Yes	Yes
Transport SMI Prot Error	Yes	Yes	Yes
Timeout Error	Yes	Yes	Yes
SysEvent Error	Yes	Yes	Yes
SysCo Error	Yes	Yes	Yes
Software Prog Error	Yes	Yes	No
Unsupported Msg Error	No	No	No
Placeholder Error	No	No	Yes

CHI-AIU			
Native Intf Write Resp Write Data Error	Yes	Yes	No
Native Intf Read Resp Error	No	No	No
Native Intf Snoop Resp Error	Yes	Yes	No
Decode Error	Yes	Yes	No
Transport TargID Error	Yes	Yes	Yes
Transport SMI Prot Error	Yes	Yes	Yes
Timeout Error	Yes	Yes	Yes
SysEvent Error	Yes	Yes	Yes
SysCo Error	Yes	Yes	Yes
Software Prog/No credits Error	Yes	Yes	No
Software Prog/Unconnected DMI Error	Yes	Yes	No
Software Prog/Unconnected DII Error	Yes	Yes	No
Software Prog/Unconnected DCE Error	Yes	Yes	No
Interface Checker Error	Yes	Yes	Yes
Unsupported Msg Error	Yes	Yes	No
Placeholder Error	No	No	Yes
DCE			
Data Snoop Filter Error	Yes	Yes	Yes
Transport TargID Error	Yes	Yes	Yes
Transport SMI Prot Error	Yes	Yes	Yes
Timeout Error	Yes	Yes	Yes
Software Prog/No credits Error	Yes	Yes	No
Software Prog/Unconnected DMI Error	Yes	Yes	No
Decode/Multi-hit Error	Yes	Yes	No
Decode/No-hit Error	Yes	Yes	No
SysEvent Error	Yes	Yes	No
DVE			
Data Trace Buf Error	Yes	Yes	Yes
Transport TargID Error	Yes	Yes	Yes
Transport SMI Prot Error	Yes	Yes	Yes
Timeout Error	Yes	Yes	No
DII			
Native Intf Write Resp Write Data Error	Yes	Yes	No
Native Intf Read Resp Error	Yes	Yes	No
Transport TargID Error	Yes	Yes	Yes
Transport SMI Prot Error	Yes	Yes	Yes

Placeholder Error	No	No	Yes
DMI			
Data Read/Write Buf Error	Yes	Yes	Yes
Cache Tag/Data Error	Yes	Yes	Yes
Native Intf Write Resp Write Data Error	Yes	Yes	No
Native Intf Read Resp Error	Yes	Yes	No
Transport TargID Error	Yes	Yes	Yes
Transport SMI Prot Error	Yes	Yes	Yes
Software Prog/Atomic w/o CCP Error	Yes	Yes	No
Placeholder Error	No	No	Yes
Timeout Error	Yes	Yes	Yes
SysEvent Error	Yes	Yes	No

TABLE 3 UNCORRECTABLE ERRORS

Correctable Error Type	Logged Detected	Generates Interrupt	Generates Mission Fault with Resiliency
IOAIU			
Data OTT Error	Yes	Yes	No. cerr_over_thres asserted after threshold met.
Cache Tag/Data Error	Yes	Yes	No. cerr_over_thres asserted after threshold met.
Placeholder Error	No	No	No. cerr_over_thres asserted after threshold met.
Transport SMI Prot Error	Yes	Yes	No. cerr_over_thres asserted after threshold met.
CHI-AIU			
Transport SMI Prot Error	Yes	Yes	No. cerr_over_thres asserted after threshold met.
Placeholder Error	No	No	No. cerr_over_thres asserted after threshold met.
DCE			
Data Snoop Filter Error	Yes	Yes	No. cerr_over_thres asserted after threshold met.

Transport SMI Prot Error	Yes	Yes	No. cerr_over_thres asserted after threshold met.
DVE			
Data Trace Buf Error	Yes	Yes	No. cerr_over_thres asserted after threshold met.
Transport SMI Prot Error	Yes	Yes	No. cerr_over_thres asserted after threshold met.
DII			
Placeholder Error	No	No	No. cerr_over_thres asserted after threshold met.
Transport SMI Prot Error	Yes	Yes	No. cerr_over_thres asserted after threshold met.
DMI			
Data Read/Write Buf Error	Yes	Yes	No. cerr_over_thres asserted after threshold met.
Cache Tag/Data Error	Yes	Yes	No. cerr_over_thres asserted after threshold met.
Transport SMI Prot Error	Yes	Yes	No. cerr_over_thres asserted after threshold met.
Placeholder Error	No	No	No. cerr_over_thres asserted after threshold met.

TABLE 4 CORRECTABLE ERRORS

1.6 Address Map Decode, Software Programming and Configuration Error Logging and Interrupt

AIU and DCE detects and logs the following Uncorrectable Errors upon address decoding, If multiple of these errors are reported for the same transaction, then reporting order of priority is from top to bottom as below:

- No Address Hit
  - If the target cannot be found in the address map
  - Or if AIUs want to issue CSR access when it is not allowed
- Multiple Address Hit
  - If multiple targets are found in the address map
- Illegal Security Access
  - If Non-Secure transaction access secure region as configured in the address map
- Illegal CSR Access Format
  - If the target is decoded as 32-bit CSR DII, and the following requirements are not met
    - 4 Byte
    - Size-aligned
    - EndPoint order
    - Device Transaction
- Illegal DII Access Type
  - Coherent access on DII
- Unconnected DMI Unit Access
  - If the target DMI as decoded by the address map is not connected to the AIU
- Unconnected DII Unit Access
  - If the target DII as decoded by the address map is not connected to the AIU
- Unconnected DCE Unit Access
  - If the target DCE as decoded by the address map is not connected to the AIU
- No Credits Configured for Access
  - If the target as decoded by the address map does not have any credits configured

If DecErrDetEn = 1:
No Address Hit/Multiple Address Hit/ Illegal Security Access/Illegal CSR Access Format/Illegal DII Access Type is logged as ErrorType Code 0x7 with errorinfo and location.
An Uncorrectable interrupt is raised if DecErrIntEn = 1.

If SoftwareProgConfigErrEn = 1:
Unconnected DMI Unit Access/ Unconnected DII Unit Access/ Unconnected DCE Unit Access/No Credits Configured for Access is logged as ErrorType Code 0xC with errorinfo and location.
An Uncorrectable interrupt is raised if SoftwareProgConfigErrIntEn = 1.

In addition, an AIU needs to complete the protocol and return error in the response.

- ACE/ACE-LITE/AXI: DECERR
- CHI: non-data error

A DCE needs to drop the recall transaction, i.e., pretend it finished successfully. In the case of ‘no credits configured for access’ error (Mrd Credits), DCE must issue an address error with in the CmStatus field of the StrReq.

1.7 CCMP Completion

AIU does not expect DtrReq if StrReq contains error CmStatus for a read request, and it needs to manufacture response to the processor.
For Writes associated transactions, if StrReq contains error CmStatus, AIU does not issue DtwReq to DMI/DII, and it needs to complete the protocol flow to the Native Interface Agent with proper error response.

When IOAIU detects an OTT data buffer uncorrectable error: ErrorType Code 0x0 with errorinfo and location

- DtwReq is returned with CmStatus = 8'b10000011 (Data Error) and poison bit set. If error is not detected on first beat, then only poison bit is set (writes)
- Data that is to be stored in cache the poison bit is set
- If the data is to be sent on to the native interface i.e., R Channel, Rresp is returned with SLVERR (Reads)
- If the data is NOT in use by the original transaction, the error is ignored. i.e., original transactions of CleanUnique/MakeUnique, CMOs, DVMs, CacheStashing, etc.

When IOAIU is configurated with cache: ErrorType Code 0x1 with errorinfo and location

- For a tag Uncorrectable Error during cache lookup due to native interface request, IOAIU treats the request as a cache miss and furthermore does not allocate to the cache. In this case uncorrectable error is logged in CSRs and reported via interrupt.
- For a tag Uncorrectable Error during SnpReq lookup, IOAIU issues SnpRsp with CmStatus = 8'b10000100 (Address Error).
- For a data Uncorrectable Error upon access cache data RAM, if first beat data is poisoned and DtrReq/DtwReq is returned with CmStatus = 8'b10000011 (Data Error) and poison bit set, if a data beat after the first beat is poisoned then only poison bit is set and CmStatus may not indicate error. In the case where data is to be provided on the native interface i.e. R Channel, Rresp is returned with SLVERR on the appropriate data beat.

When IOAIU processes a multi-line transaction:

- For read transaction each individual Cache line is for error reporting purposes is treated separately as if it was a single cache line transaction. Requirements are defined in the section above
- For write transaction the final response on the native interface must be the accumulation of all individual cache line write responses. Here Address error (DECERR) has higher precedence than (SLVERR).

When DCE gets a snoop filter look up error: ErrorType Code 0x0 with errorinfo and location

- DCE issues StrReq with CmStatus = 8'b10000100 (Address Error).

When DCE is configured with zero DMI credits: ErrorType Code 0xC with errorinfo and location

- DCE issues StrReq with CmStatus = 8'b10000100 (Address Error).

When DCE gets any SnpRsp error: Refer to CHI.F chapter 9 Error Handling:

- For invalidating snoop: *SnpInvDtw, SnpInvDtr, SnpInv, SnpInvStsh, SnpUnqStsh, SnpStshUnq, SnpNITCCIDtr, SnpNITCMIDtr*
  - If a snooped AIU returns SnpRsp error, DCE clears the corresponding snoopee entry in SF (even if the SnpRsp without error DCE still clears the snoopee status in SF since it is a invalidating snoop)
  - If non of snooped AIUs provides the data, then DCE issues StrReq with propagated error CmStatus from the last received SnpRsp error. And the requester's status in SF remains unchanged.
  - If one of the snooped AIU provides the data, the protocol is completed by the DtrReq/DtwMrgMrdReq and the error is not propagated by DCE via StrReq. And the requester's status is updated as if there is no error.
- For non-invalidating snoop: *SnpNITCDtr, SnpClnDtr, SnpVldDtr, SnpNoSDIntDtr, SnpVldDtw*
  - If the snooped AIU returns SnpRsp error, DCE DOES NOT change the status of requester and snoopee in SF, DCE issues StrReq with propagated error CmStatus from SnpRsp.
  - If the snooped AIU provides the data, the protocol is completed by the DtrReq/DtwMrgMrdReq and the error is not propagated by DCE via StrReq. And the requester's status is updated as if there is no error.
- In the case of Read Stash
  - If non-target snooped AIU returns SnpRsp error DCE does not propagate it (and issues MrdReq to complete the request if target snooped AIU accepts the stash)
  - If target snooped AIU returns SnpRsp error, DCE propagates the error on StrReq and aborts the transaction
- In the case of Write stash
  - If non-target snooped AIU returns SnpRsp error, DCE clears the corresponding snoopee entry in SF, and the error is not propagated
  - If target snooped AIU returns SnpRsp error, DCE clears the corresponding snoopee entry in SF, the error is not propagated and proceed as stash decline
- In the case of Write Unique SnpRsp errors are not propagated onto to StrReq, DCE clears all snoopee entry in SF, and the write part proceed

When DMI is configurated with cache: ErrorType Code 0x1 with errorinfo and location

- For a tag Uncorrectable Error during SMC lookup due to CmdReq/MrdReq/DtwMrgMrdReq messages, DMI issues a control propagation DtrReq message that indicates an address corruption error. In addition, the DMI manufactures appropriately sized and poisoned data payload for the DtrReq with CmStatus = 8'b10000100 (Address Error). Since the entire data payload is poisoned, the actual content of the payload is not important.
- For a tag error during SMC lookup due to a prefetch message, DMI drops the message. Since DMI return early StrRsp/MrdRsp for prefetch transaction, no error is propagated.
- For a data Uncorrectable Error upon access SMC data RAM, data is poisoned and DtrReq is returned with CmStatus = 8'b10000011 (Data Error)

When DVE gets a SnpRsp error:

- DVE issues CmpRsp with CmStatus = 8'b10000100 (Address Error).

CmStatus error is propagated only on following responses:

- SnpRsp coming into DCE, only if no other related SnpRsp issued a DtrReq/DtwMrgMrdReq then this is propagated on to StrReq else it is not propagated on to StrReq
- DtwRsp coming into AIUs, this is propagated on to the native interface
- MrdRsp coming into DCE, this is propagated on to StrReq(for CMOs to SMC)
- CmpRsp coming into AIUs, this is propagated on to the native interface

CmStatus error is propagated only on following requests:

- StrReq going out of DCE

- DtrReq going out of AIUs, DMI, and DII
- DtwReq going out of AIUs

In the case of coherent Atomic transactions, where there are two parts the coherent part (clean operation with DCE) and the non-coherent part (atomic transaction with DMI) following applies:

- If an error is reported back to the initiating AIU during the first coherent part, then the error is propagated on the Native interface and the second part is not carried out. Note that the AIU is expected to issue proper response and deallocate its transaction entry.
- If an error is reported back to the initiating AIU during the second non-coherent part, then the error is propagated on the Native interface. Note that the AIU is expected to issue proper response and deallocate its transaction entry.
- For Atomic Load/Swap/Compare where the Bresp and Rdata/Rresp is required, two responses can report different types of error from DtwRsp and DtrReq. An AIU needs to wait for both responses and return a consolidated identical response back to the Native interface.
- The priority of error types is: Address Error (DECERR) > Data Error (SLVERR) > OK
- In case of DMI receives Atomic Transaction but without CCP configured or enabled, Software Programming or Configuration Error is reported

In the case of ACE and IOAIU with proxy cache configurations where WriteBacks, WriteClean, WriteEvict, Evict and cache eviction can have two parts i.e. non-coherent write to DMI and coherent update to DCE. If an error is reported back during the non-coherent transaction part, then the coherent update part needs to be completed. In the case of ACE the error needs to be propagated on the native interface.
In the case of CHI AIU where WriteBacks, WriteClean, WriteEvict, Evict, the protocol semantics must be fulfilled.
AIU DOES NOT propagate error on UpdReq, therefore DCE updates SF as if there is no error.
DtwReq is not allowed to be sent if AIU receives StrReq with error, it need to complete the protocol by manufacturing response to the native interface if necessary.

1.8 Data Poisoning

In DMI, if DBad is asserted on DtwReq, it will not log error and just return normal CmStatus in DtwRsp.
In this case, AIUs will not respond error to native interface.
If the DtwReq is written into SMC, DMI will set the poison bit of the DtwReq beat.
If the DtwReq is written to downstream AXI, DMI will deassert the write strobes of the DtwReq beat.

In DMI, if any Address Error is detected, the poison bits of whole cache line will be set and propagate on DtrReq.
Otherwise, poison bits are propagated in per DtrReq beat based.
Note that there can be cases where the CmStatus of the DtrReq and DtwReq may not report the error but DBad may be set. This happens in cases where the error was detected after processing the first beat of data.

In case of CHIAIU or IOAIU without proxy cache, please refer to chapter 1.3.
In case of IOAIU with proxy cache:

1. For non-coherent or non-cachable or cache miss without allocation transactions, follow the rule as IOAIU without proxy cache, chapter 1.3.
2. For full CCP Data Width write hit, the poison bit of the CCP will be overwritten by write data
3. For partial CCP Data Width write hit, it will result in a RMW, and if either write data from AXI or data in CCP is corrupted, the poison bit will be set
4. For full cache line write miss, CCP DO NOT generate linefill request and when allocation is done, it will proceed as **2. full CCP data width writes hit**, and the poison bit will be overwritten by write data
5. For partial cache line write miss, CCP will generate linefill request, so the fill data now comes from 2 part AXI write data and DtrReq, if BEs from AXI write data of entire CCP beat are set, the poison bit of that beat will be overwritten with poison bit from AXI write data.

In summary, Ncore guarantee the granularity of poison bit to be AXI/ACE/CHI Data width = CCP Data width = Dtw/DtrReq data packet width, if requesters perform full writes of the granularity of the memory location, Ncore will overwrite the poison bit, otherwise the poison bit is preserved.

1.9 Timeout Error

Timeout mechanism is implemented in AIUs, DCEs, DVEs, DMIs and DIIs; All Tracking Tables inside a Ncore Unit implement a Timeout Detection logic and Handling logic.

Timeout Detection:

One global counter is designed to count cycles. Once the counter reaches a programmable threshold, the timeout overflow bit in all valid entries is set. The timeout overflow bit will be cleared if the entry deallocates. If the global counter reaches the threshold again while the timeout overflow bit is still set, then that entry has timed out. The event is logged in an error register to allow an interrupt to be raised if enabled.

Timeout Handling:

The status is logged in the CSR, software have the option to either disable timeout and continue or treat this as a fatal error. The timeout counter will stop running, until software restarts it via CSR.

ErrorType Code 0x9 with errorinfo and location

1.10 Sys event and SysCo Errors

Each type of timeout error below has its own timeout counter and CSR setting.

1. Sys Event Protocol Timeout: Sys event sender can report a timeout error if it does not get a SysRsp message for the SysReq it sent out. ErrorType Code 0xA
2. Sys Event Handshake Timeout: Sys event receiver can report a timeout error if it does not get an ack back on the event pins. ErrorType Code 0xA
3. Sys Co Protocol Timeout: Sys Co handler can report a timeout error if it does not get a SysRsp message for the SysReq it sent out. ErrorType Code 0xB

1.11 Unsupported Message Type

If Ncore units receive an unsupported CCMP Message (for example DMI gets a snoop command), the message will not be processed and eventually trigger a timeout error. No error is reported in these cases.

In case of Ncore AIUs receive an unsupported transaction, the transaction will be resolved inside AIUs and will not generate further CCMP messages to Ncore system. The AIU should return Non-Data Error/DECERR to the Native Interface.
The AIU also needs to finish transaction semantics by generating required messages such as DBIDresp, etc.
Uncorrectable Error is logged when AIUs does not support the transaction, or the transaction is decoded into unknown if ProtErrDetEn = 1. An Uncorrectable interrupt is raised if ProtErrIntEn = 1.
ErrorType Code 0xE with errorinfo and location

1.12 Error Reporting in CMStatus

If multiple errors are detected in a message, NCore Unit will report control errors (eg. Address Error) over data error in CmStatus.

1.13Interface Checker Error

Ncore AIUs support a placeholder at Native Interface side for customers to insert their customed Native Interface protection algorithm, eg SECDEC ECC, Parity, etc. Upon an error happens, the Checker will drop the messages.

If IntfCheckErrDetEn = 1, the Interface Checker will detect and log any message that contains an error. ErrorType Code 0xD with errorinfo (the channel of where the error is detected)

An Uncorrectable interrupt is raised if IntfCheckErrIntEn = 1.

2 Opens

Questions/Feedback/Need to discuss:

3 Glossary

Arteris

A NoC Company

NCore3

A coherent NoC provided by Arteris with AMBA interfaces and built-in caches.

4 Notes

Notes ……