RMAP Protocol

SpaceWire Working Group
February 2005

Washington

Aim of RMAP

- Provide a means of
  - Writing to
  - Reading from
  - Registers or memory on a SpaceWire node
  - Over a SpaceWire network
  - Registers are considered to be memory mapped
- Be simple and effective

Trade-off Criteria

- Shortest possible commands vs easier/faster to decode
- Aligned fields across commands vs not aligned
- 32-bit alignment vs byte alignment only
- Simplest baseline set with more complex extensions/options

Changes since last meeting

- *Indirect read and write commands removed*
- *Validate before write option added*
- *Read-modify-write command included.*

Posted Operations

- All read and write operations defined in the RMAP protocol are posted operations
- I.e. source does not wait for acknowledgement or reply to be received
- Many reads and writes can be outstanding at any time
- Means that no timeout mechanism implemented in RMAP for missing acknowledgements or replies
- If acknowledgement or reply timeout mechanism is required it must be implemented in the source user application.

Write Commands

- Write non-acknowledged, non-verified
  - Writes zero or more bytes to memory in a destination node
  - Command is checked using a checksum before the data is written
  - Data is not checked before it is written
  - No acknowledgement given to indicate that the command has been successfully executed
- Used for writing large amounts of data to a destination where it can be safely assumed that the write operation completed successfully.

Write Commands

- Write non-acknowledged, verified
  - Writes zero or more bytes to memory in a destination node
  - Command and data are both checked using checksums before the data is written
  - Limits the amount of data that can be transferred in a single write operation
  - Owing to limited buffer space in destination
  - Erroneous data cannot be written to memory
  - No acknowledgement given to indicate that the command has been successfully executed
- Used for writing command registers and small amounts of data to a destination where it can be safely assumed that the write operation completed successfully.

Write Commands

- Write acknowledged, non-verified
  - Writes zero or more bytes to memory in a destination node
  - Command is checked using a checksum before the data is written
  - Data is not checked before it is written
  - Acknowledgement sent to indicate that the command has been successfully executed
- used for writing large amounts of data to a destination where it can be safely assumed that the write operation completed successfully, but an acknowledgement is required.
  - For example writing sensor data to memory.

Write Commands

- Write acknowledged, verified
  - Writes zero or more bytes to memory in a destination node
  - Command and data are both checked using checksums before the data is written
  - Limits the amount of data that can be transferred in a single write operation
  - Owing to limited buffer space in destination
  - Erroneous data cannot be written to memory
  - Acknowledgement sent to indicate that the command has been successfully executed
- Used for writing small amounts of data to a destination where it is important to have confirmation that the write operation was executed successfully.
  - For example writing to command or configuration registers.

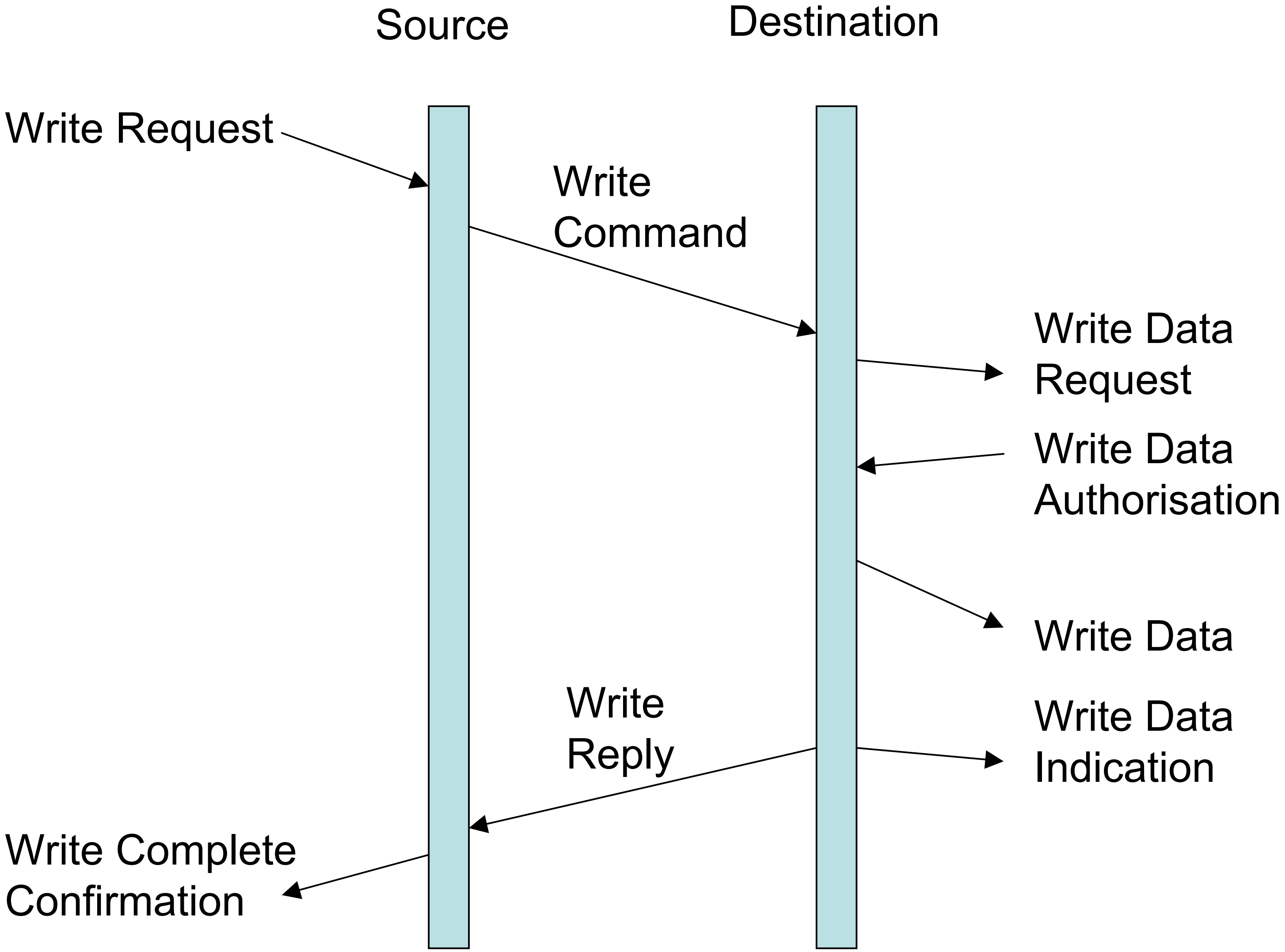
Read Command

- Read command
  - Reads one or more bytes of data
  - From specified area of memory in a destination node
  - Data read is returned in a reply packet.

Read-Modify-Write Command

- Read-modify-write command
  - Reads a register (or memory)
  - Returns its value
  - Writes a new value, specified in the command, to the register.
  - Mask can be included, in the command
  - So that only certain bits of the register are written
- Provides an atomic operation that can be used for semaphores and other handshaking operations.

Write Operation



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Write Command

First byte transmitted

	Destination Path Address	Destination Path Address	Destination Path Address
Destination Logical Address	Protocol Identifier	Packet Type, Command Source Address Extra Length	Destination Key
Extra Source Path Address	Extra Source Path Address	Extra Source Path Address	Extra Source Path Address
Source Logical Address	Transaction Identifier	Transaction Identifier	Extended Write Address
Write Address (MS)	Write Address	Write Address	Write Address (LS)
Data Length (MS)	Data Length	Data Length (LS)	Header Checksum
Data	Data	Data	Data
Data	Data	Data	Data
Data	Data Checksum	EOP	

Last byte transmitted

Bits in Packet Type / Command / Source Address Extra Length Byte

MSB LSB

Reserved = 0	Command = 1	Write = 1	Verify data before write(1)	Ack (1)/ No ack (0)	Increment/ No inc. target	Extra Source Addr Words	Extra Source Addr Words
Packet Type		Command				Source Address Extra Length	

Write Reply

First byte transmitted

	Source Path Address	Source Path Address	Source Path Address
Source Logical Address	Protocol Identifier	Packet Type, Command, Source Address Extra Length	Status
Destination Logical Address	Transaction Identifier	Transaction Identifier	Reply Checksum
EOP			

Last byte transmitted

Bits in Packet Type / Command / Source Address Extra Length Byte

MSB LSB

Reserved = 0	Response = 0	Write = 1	Verify data before write(1)	Ack =1	Increment/ No inc. target	Extra Source Addr Words	Extra Source Addr Words
Packet Type		Command				Source Address Extra Length	

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Write Command Header Error

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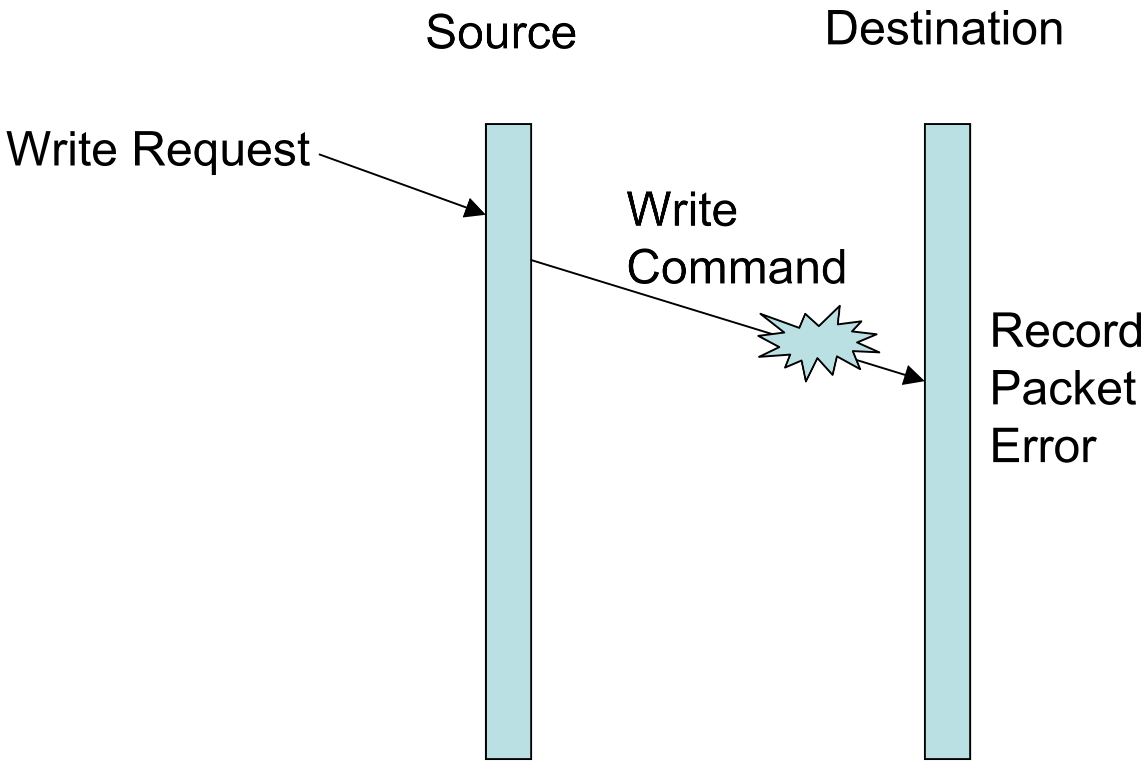
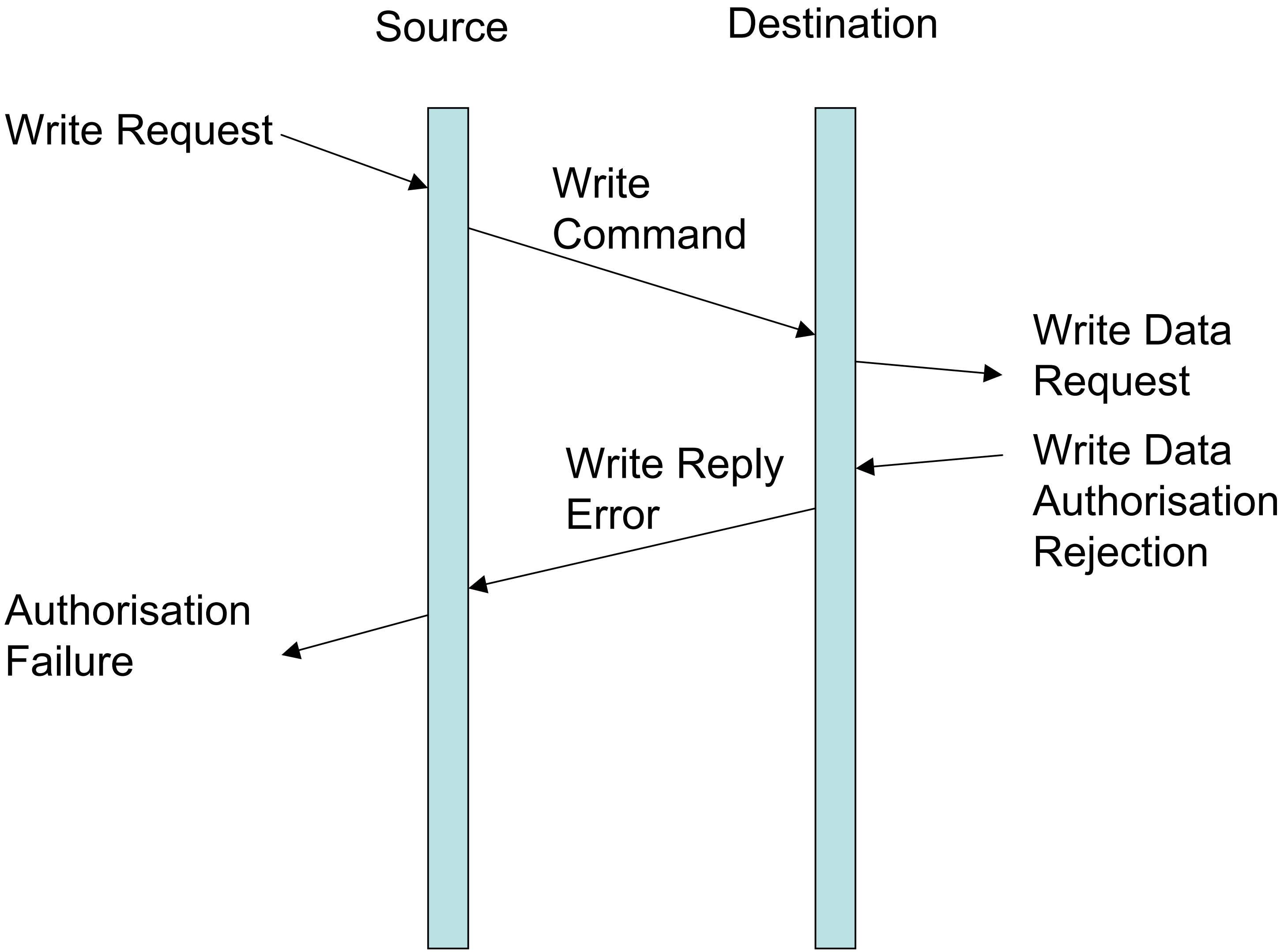


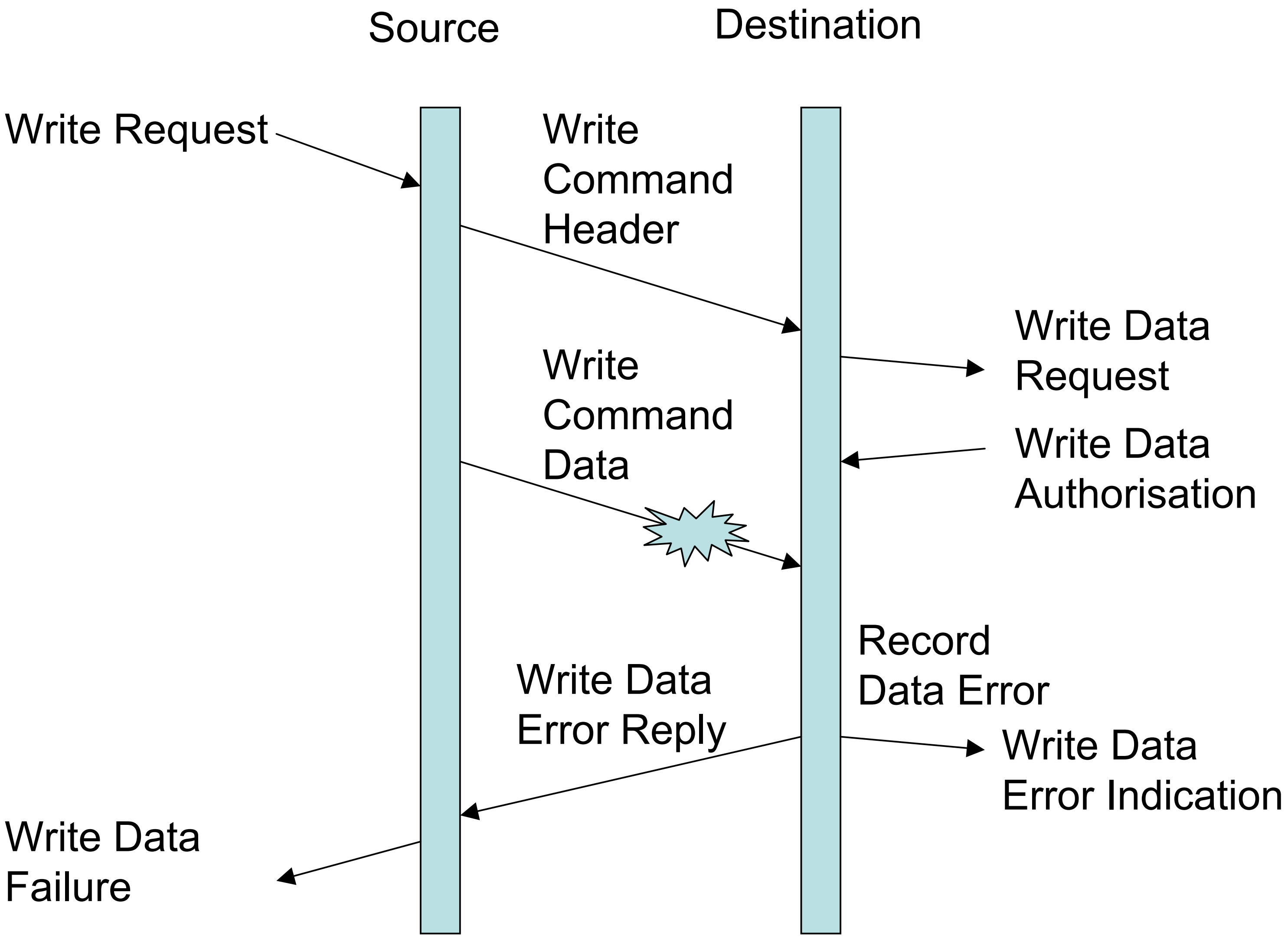
Write Authorisation Rejection



Command Authorisation

- Destination user application
- Can refuse to authorise command for any reason
- E.g.
  - Write address not 32-bit aligned
  - Length not a multiple of four bytes
  - Address range falls partially of completely outside an acceptable region

Write Data Error



Source

Destination

Write Request

Write Command Header

Write Data Request

Write Command Data

Write Data Authorisation

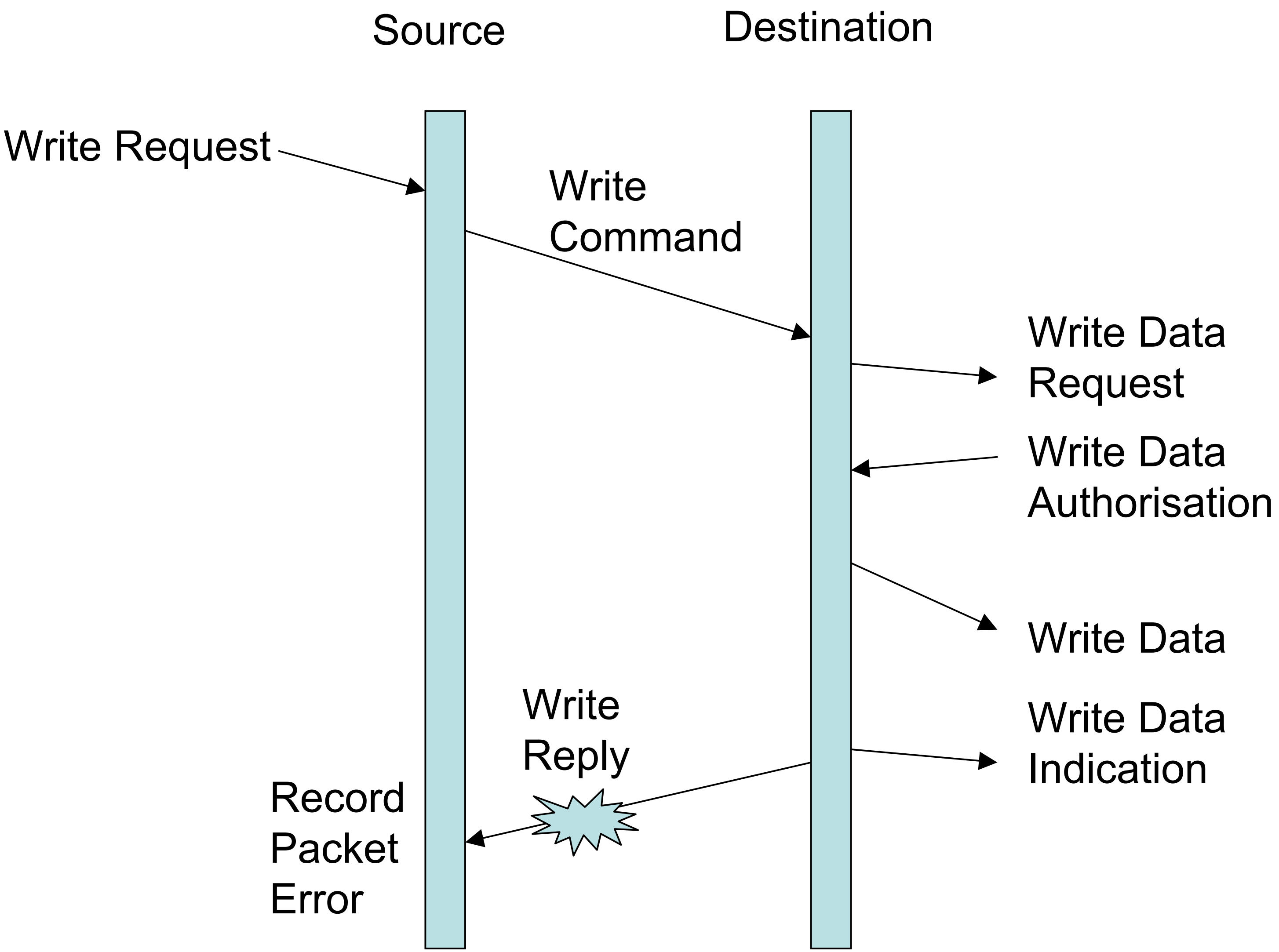
Record Data Error

Write Data Error Reply

Write Data Error Indication

Write Data Failure

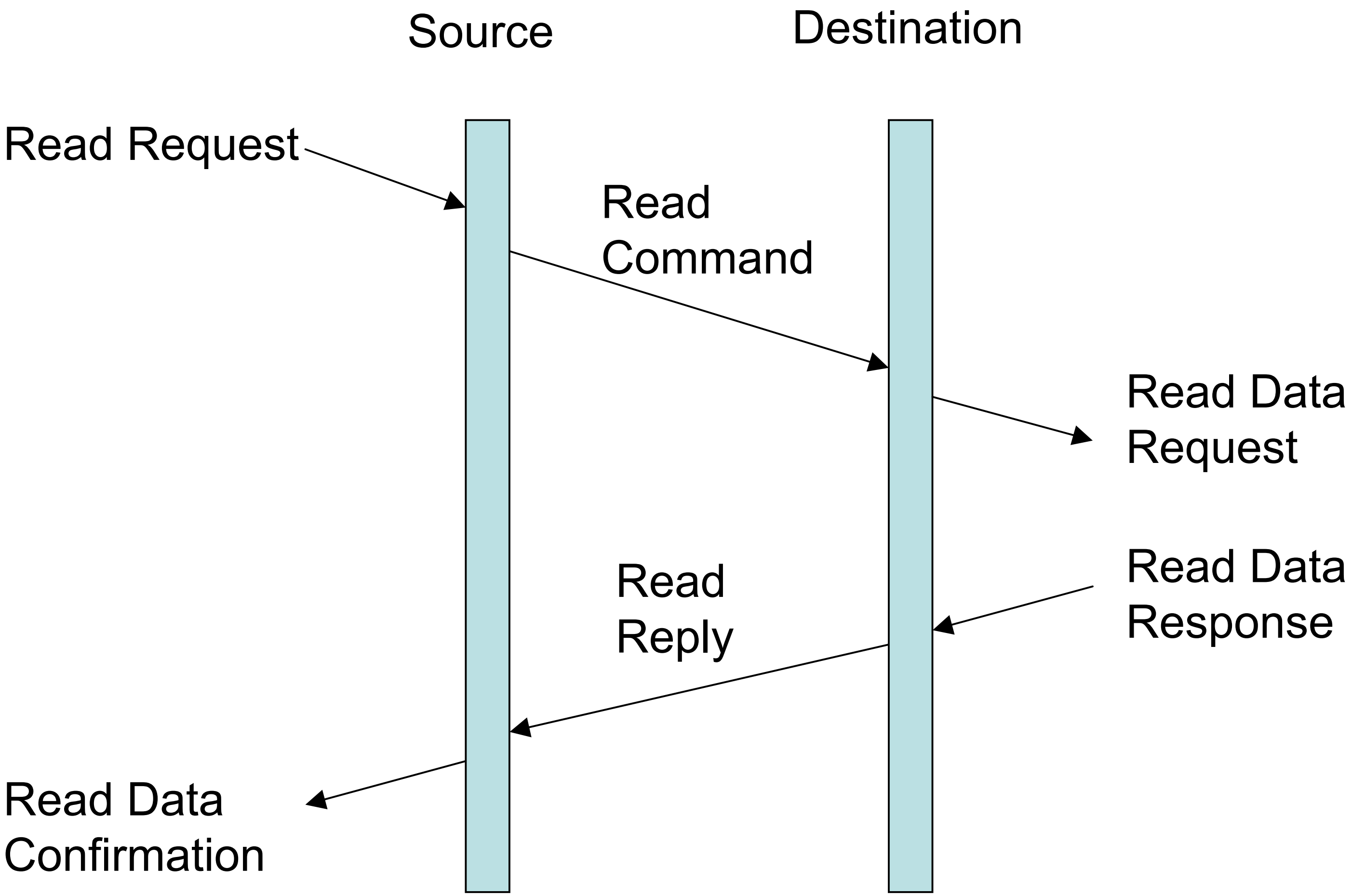
Write Reply Error



Write Command Parameters

- Destination address
- Source address
- Transaction identifier
- Destination device type
- Write command options
- Write address
- Data length
- Data

Read Operation



Source

Destination

Read Request

Read Command

Read Data Request

Read Data Response

Read Reply

Read Data Confirmation

Read Command

First byte transmitted

	Destination Path Address	Destination Path Address	Destination Path Address
Destination Logical Address	Protocol Identifier	Packet Type, Command Source Address Extra Length	Destination Device Type
Extra Source Path Address	Extra Source Path Address	Extra Source Path Address	Extra Source Path Address
Source Logical Address	Transaction Identifier (MS)	Transaction Identifier (LS)	Extended Read Address
Read Address (MS)	Read Address	Read Address	Read Address (LS)
Data Length (MS)	Data Length	Data Length (LS)	Header Checksum
EOP			

Last byte transmitted

Bits in Packet Type / Command / Source Address Extra Length Byte

MSB LSB

Reserved = 0	Command = 1	Read = 0	Read = 0	Read = 1 (Ack/No_Ack)	Increment/ No inc. target	Extra Source Addr Words	Extra Source Addr Words
Packet Type		Command				Source Address Extra Length	

Read Reply

First byte transmitted

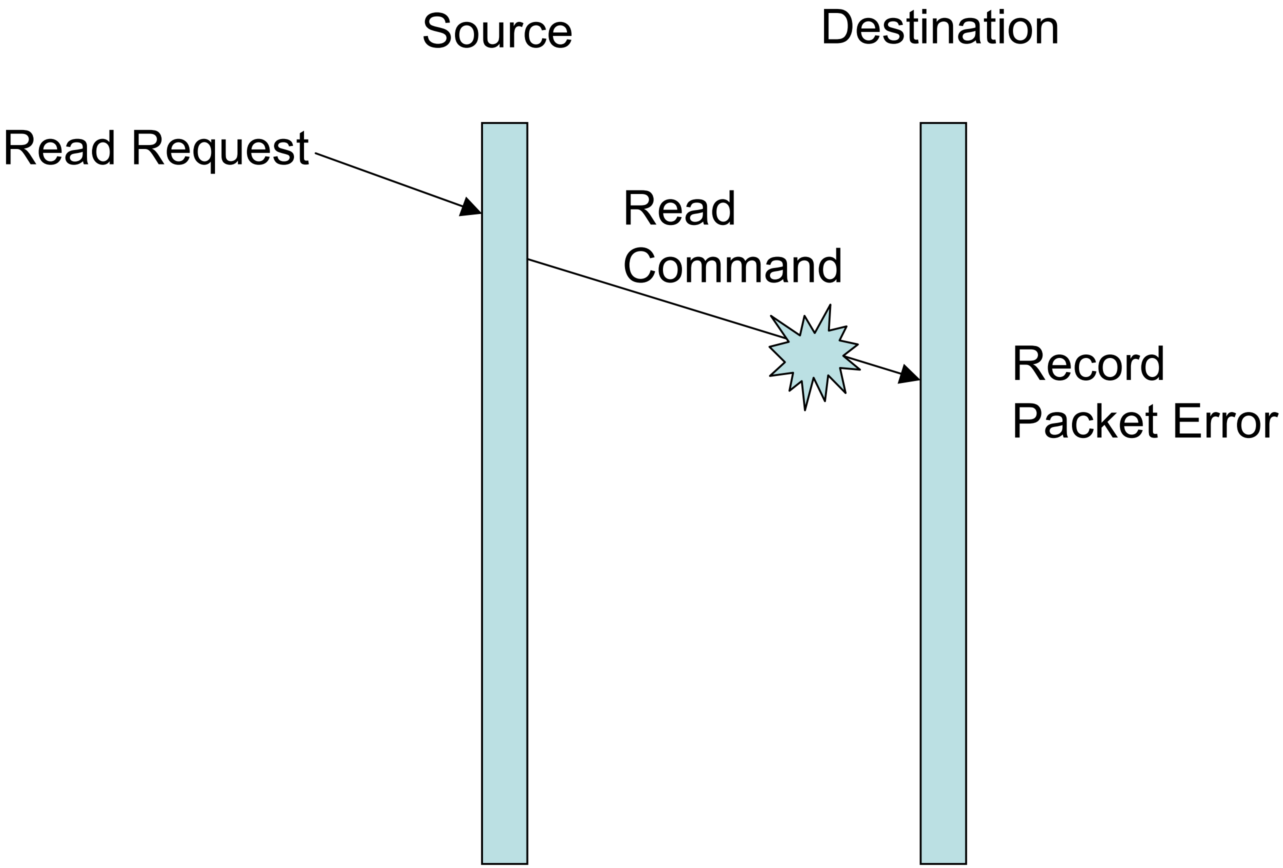
	Source Path Address	Source Path Address	Source Path Address
Source Logical Address	Protocol Identifier	Packet Type, Command, Source Address Extra Length	Status
Destination Logical Address	Transaction Identifier (MS)	Transaction Identifier (LS)	Reserved = 0
Data Length (MS)	Data Length	Data Length (LS)	Header Checksum
Data	Data	Data	Data
Data	Data	Data	Data
Data	Data Checksum	EOP	

Last byte transmitted

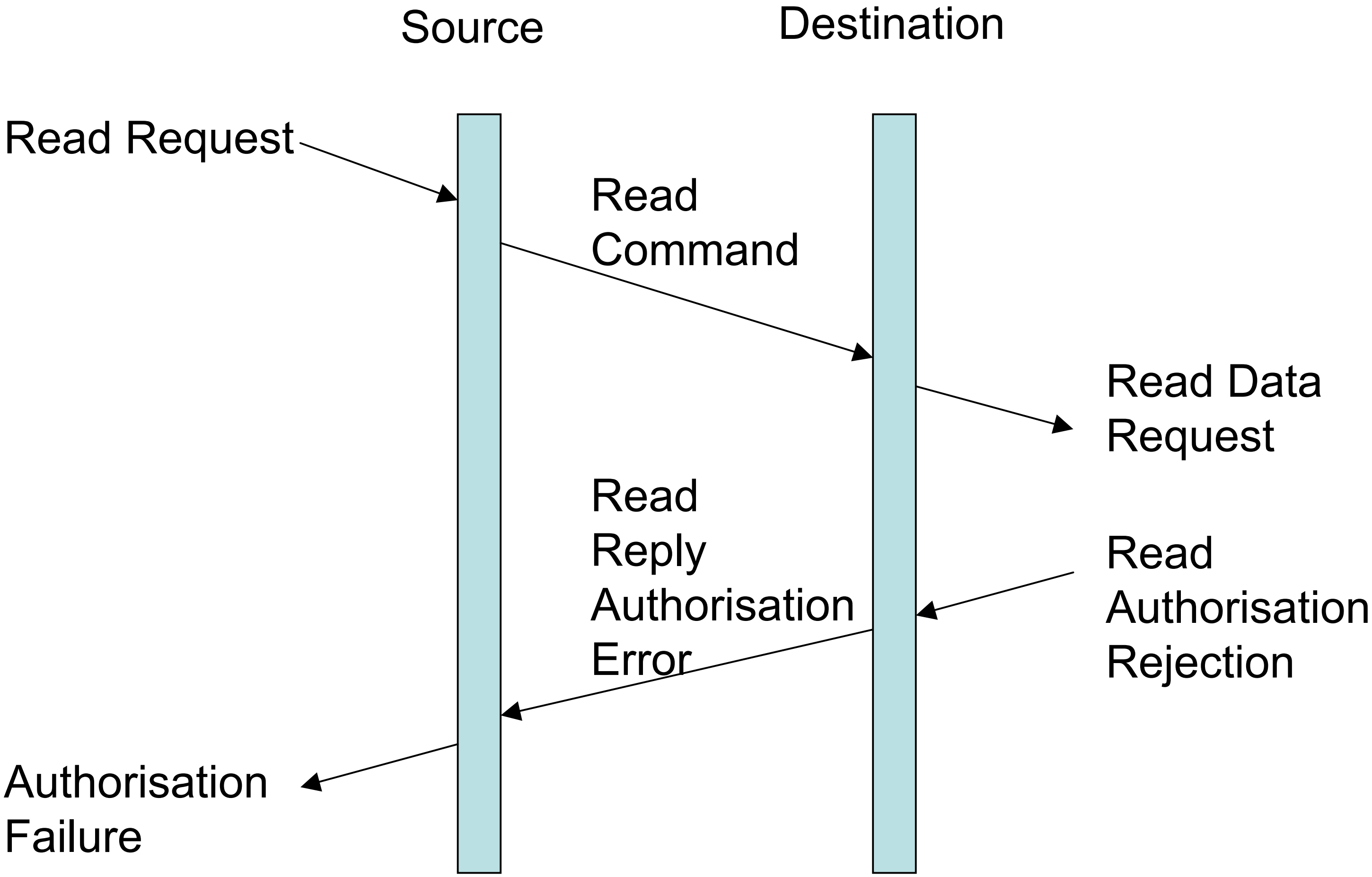
Bits in Packet Type / Command / Source Address Extra Length Byte

MSB							LSB
Reserved = 0	Response = 0	Read = 0	Read = 0	Read = 1	Increment/ No inc. target	Extra Source Addr Words	Extra Source Addr Words
Packet Type		Command				Source Address Extra Length	

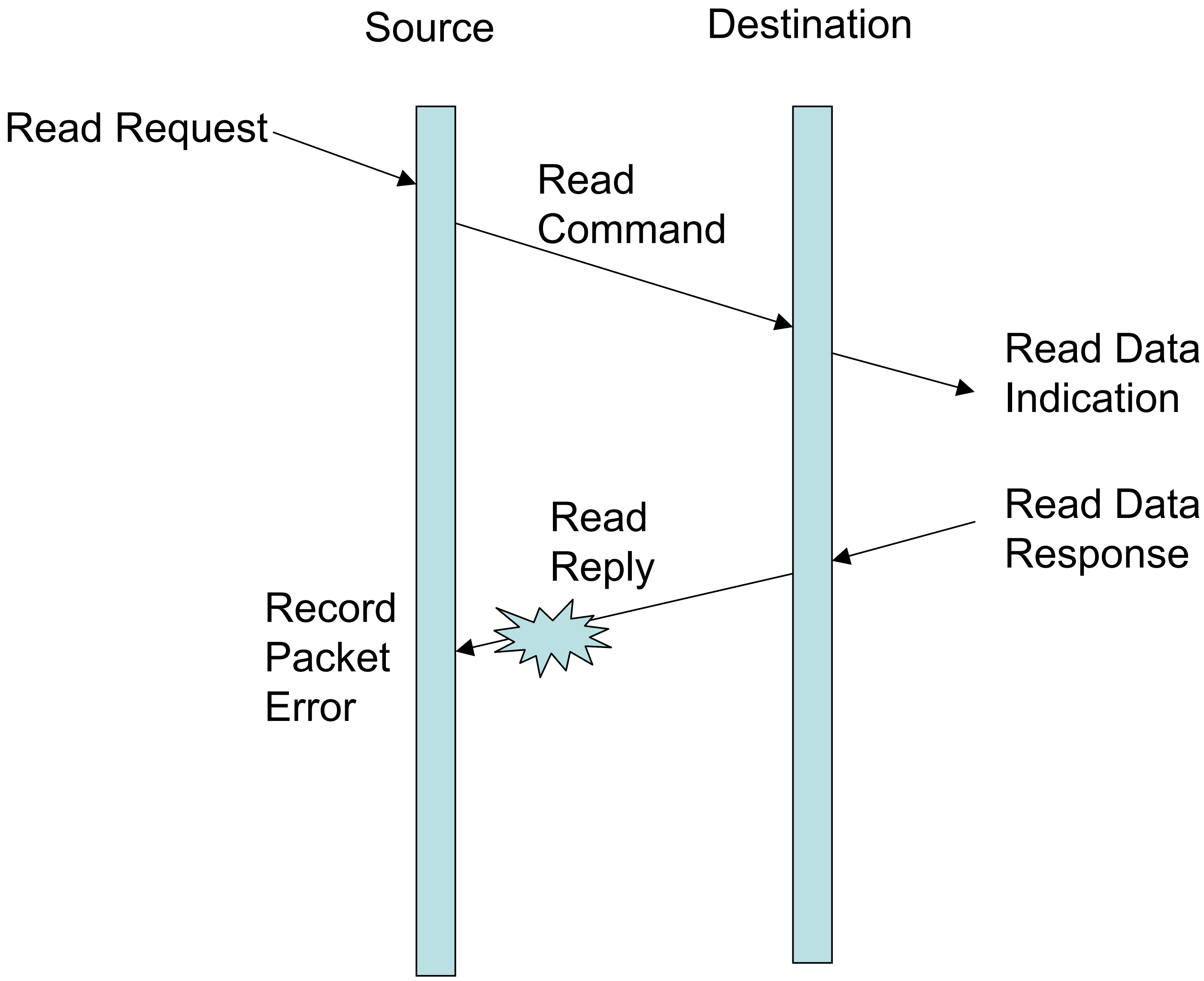
Read Command Error



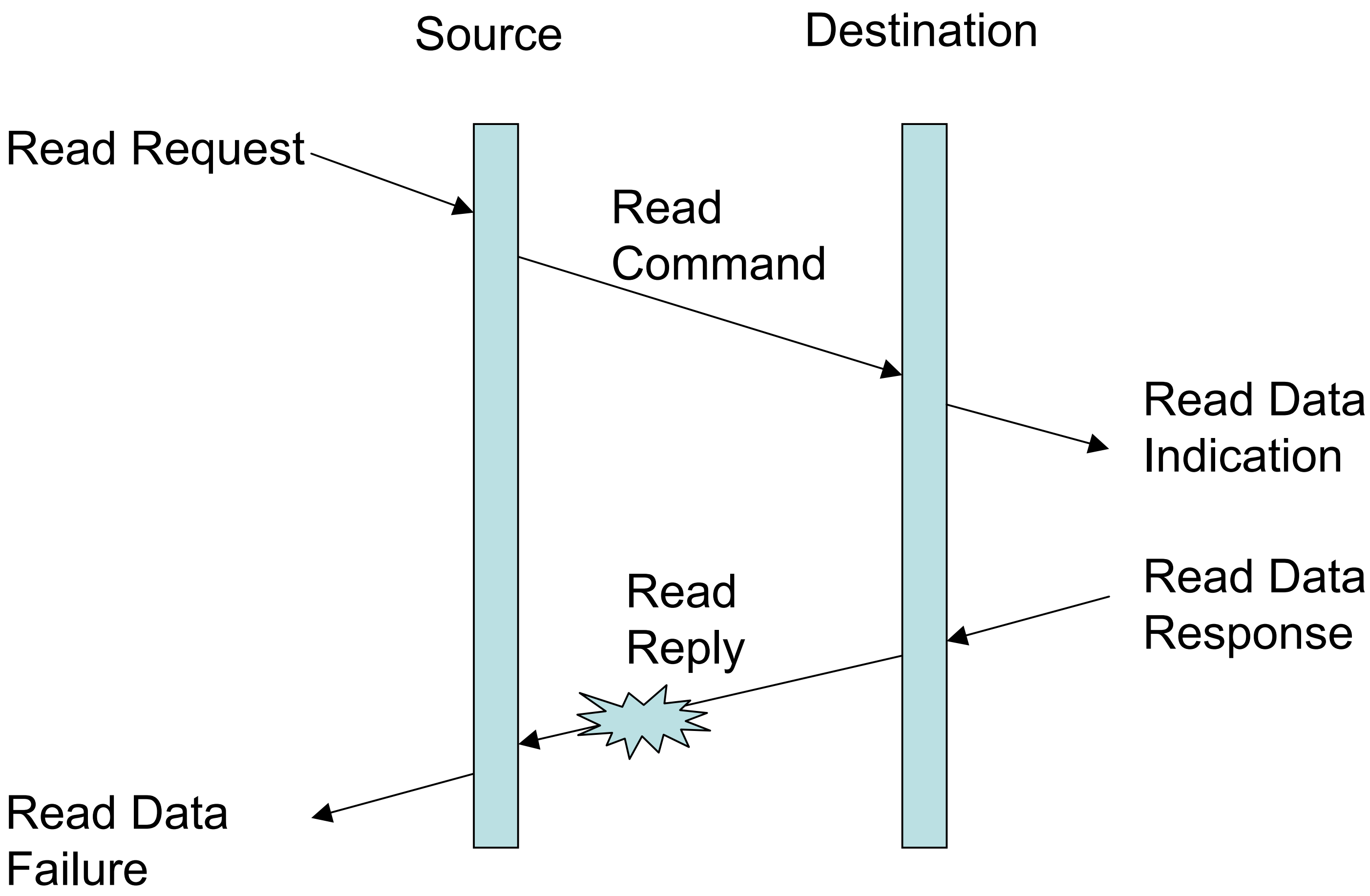
Read Authorisation Rejection



Read Reply Header Error



Read Reply Data Error

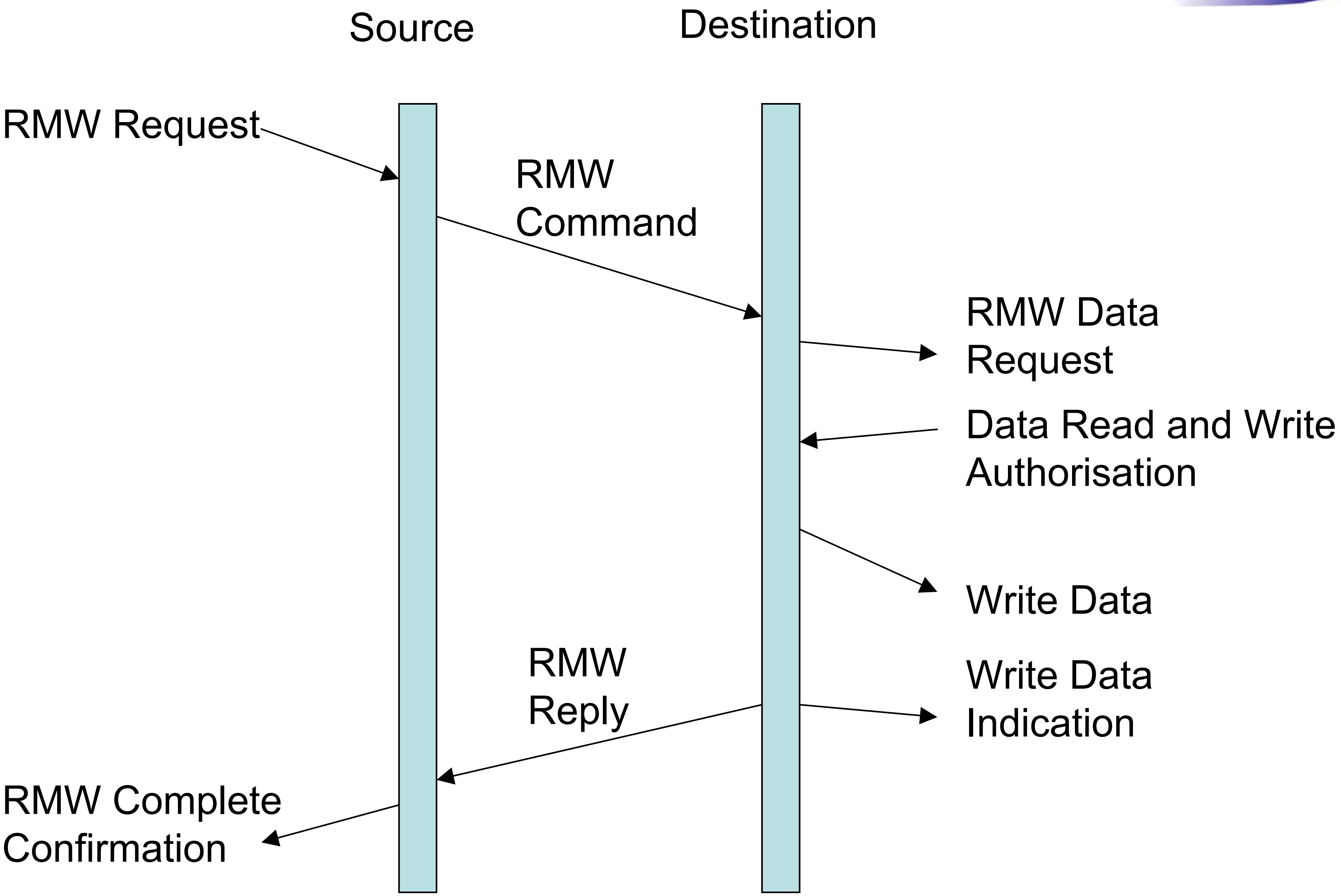


Read Command Parameters

- Destination address
- Source address
- Transaction identifier
- Destination device type
- Read command options
- Read address
- Data length

- Note RMAP does not handle the user application receive buffers
- otherwise it would have to maintain at least a pointer for every outstanding read request
- It is up to user application to handle any receive buffers.
- Appropriate receive buffer for a read reply may be identified in user application by transaction identifier in read reply.

Read-Modify-Write Operation



Source

Destination

RMW Request

RMW Command

RMW Data Request

Data Read and Write Authorisation

Write Data

RMW Reply

Write Data Indication

RMW Complete Confirmation

Read-Modify-Write Operation

1	0	0	0	1	0	0	0	Data in command (Data)
1	0	0	0	1	1	1	0	Mask in command (Mask)
1	1	1	0	0	0	1	1	Data read from destination memory and returned to source (Read)
1	1	1	0	1	0	0	1	Data written to destination memory = (Mask AND Data) OR (/Mask.Read)

Read-Modify-Write Command

First byte transmitted

	Destination Path Address	Destination Path Address	Destination Path Address
Destination Logical Address	Protocol Identifier	Packet Type, Command Return Address Extra Length	Destination Device Type
Extra Source Path Address	Extra Source Path Address	Extra Source Path Address	Extra Source Path Address
Source Logical Address	Transaction Identifier	Transaction Identifier	Extended RMW Address
RMW Address (MS)	RMW Address	RMW Address	RMW Address (LS)
Data +Mask Length (MS) = 00h	Data + Mask Length = 00h	Data + Mask Length (LS) = 00h, 02h, 04h, 06h or 08h	Header Checksum
Data (MS)	Data	Data	Data (LS)
Mask (MS)	Mask	Mask	Mask (LS)
Data/Mask Checksum	EOP		

Last byte transmitted

Bits in Packet Type / Command / Source Address Extra Length Byte

MSB LSB

Reserved = 0	Command = 1	Read = 0	Verify Data Before WR = 1	Ack/No_Ack = 1	Inc. target = 1	Extra Source Addr Words	Extra Source Addr Words
← Packet Type →		← Command →				Source Address Extra Length	

Read-Modify-Write Reply

First byte transmitted

	Source Path Address	Source Path Address	Source Path Address
Source Logical Address	Protocol Identifier	Packet Type, Command, Source Address Extra Length	Status
Destination Logical Address	Transaction Identifier (MS)	Transaction Identifier (LS)	Reserved = 0
Data Length (MS) = 0	Data Length = 0	Data Length (LS) = 01h, 02h, 03h or 04h	Header Checksum
Data	Data	Data	Data
Data Checksum	EOP		

Last byte transmitted

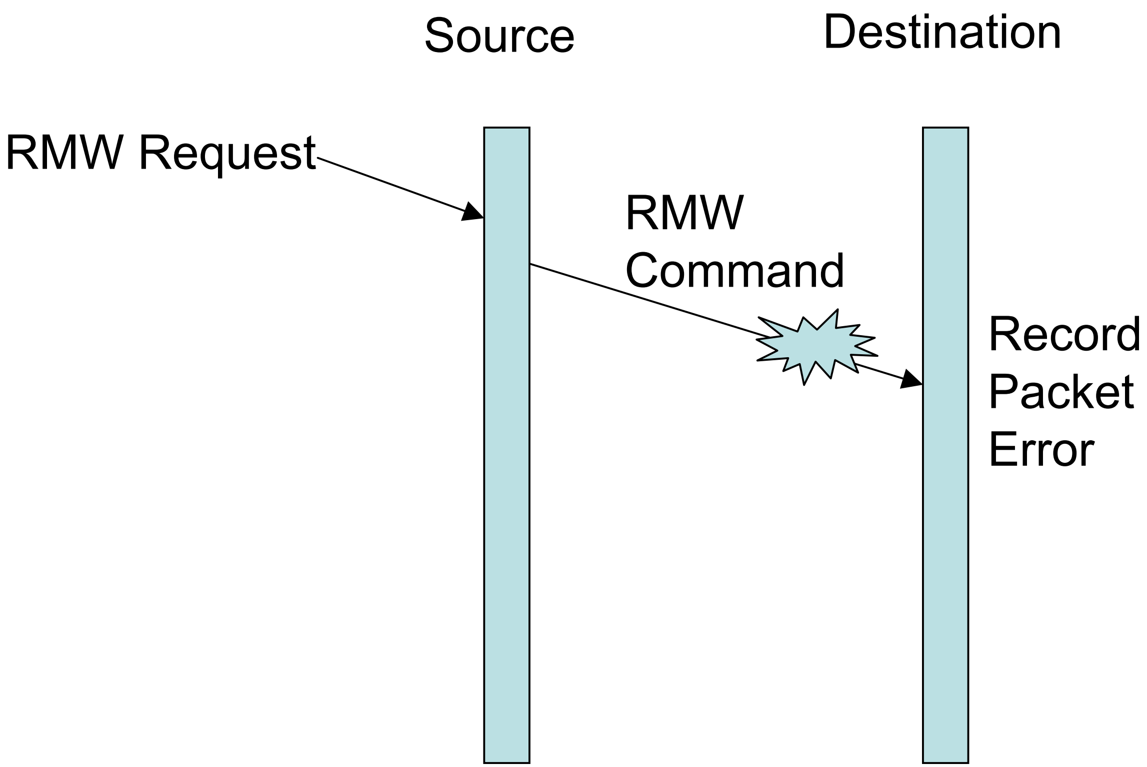
Bits in Packet Type / Command / Source Address Extra Length Byte

MSB LSB

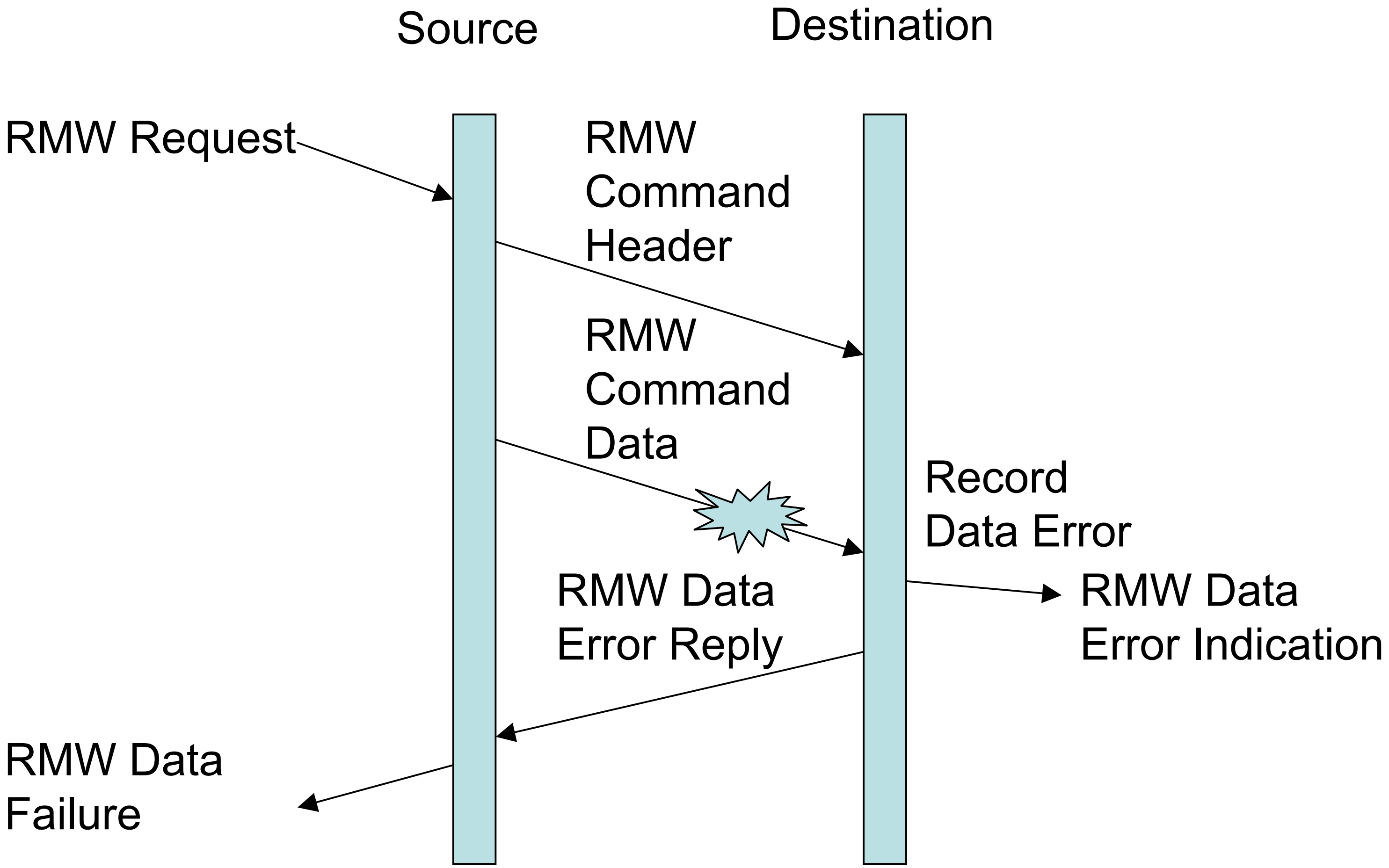
Reserved = 0	Response = 0	Read = 0	Verify Data Before WR = 1	Ack/No_Ack = 1	Inc. target = 1	Extra Source Addr Words	Extra Source Addr Words

Packet Type | Command | Source Address Extra Length

RMW Command Header Error



RMW Command Data Error



Source

Destination

RMW Request

RMW Command Header

RMW Command Data

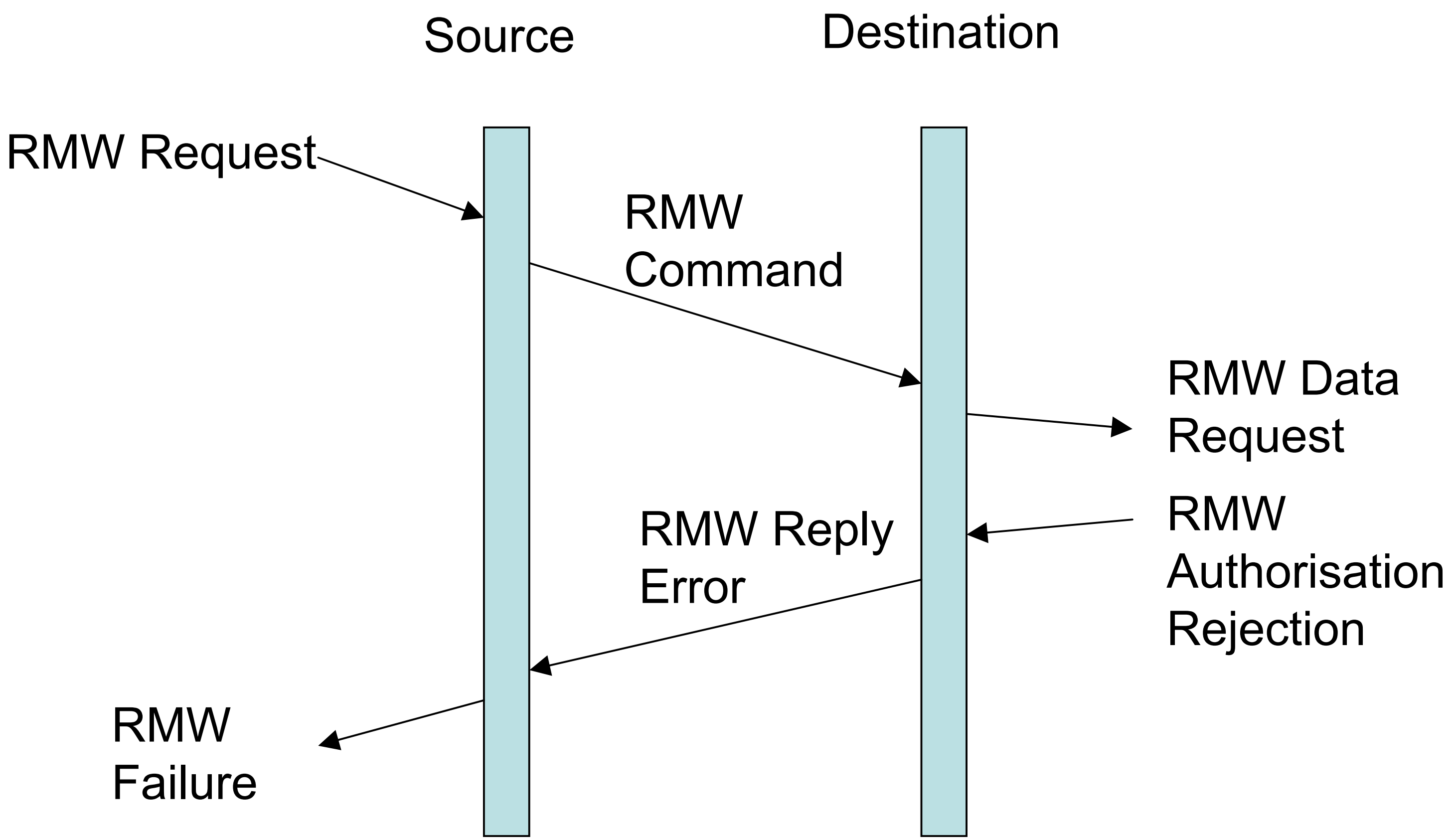
Record Data Error

RMW Data Error Indication

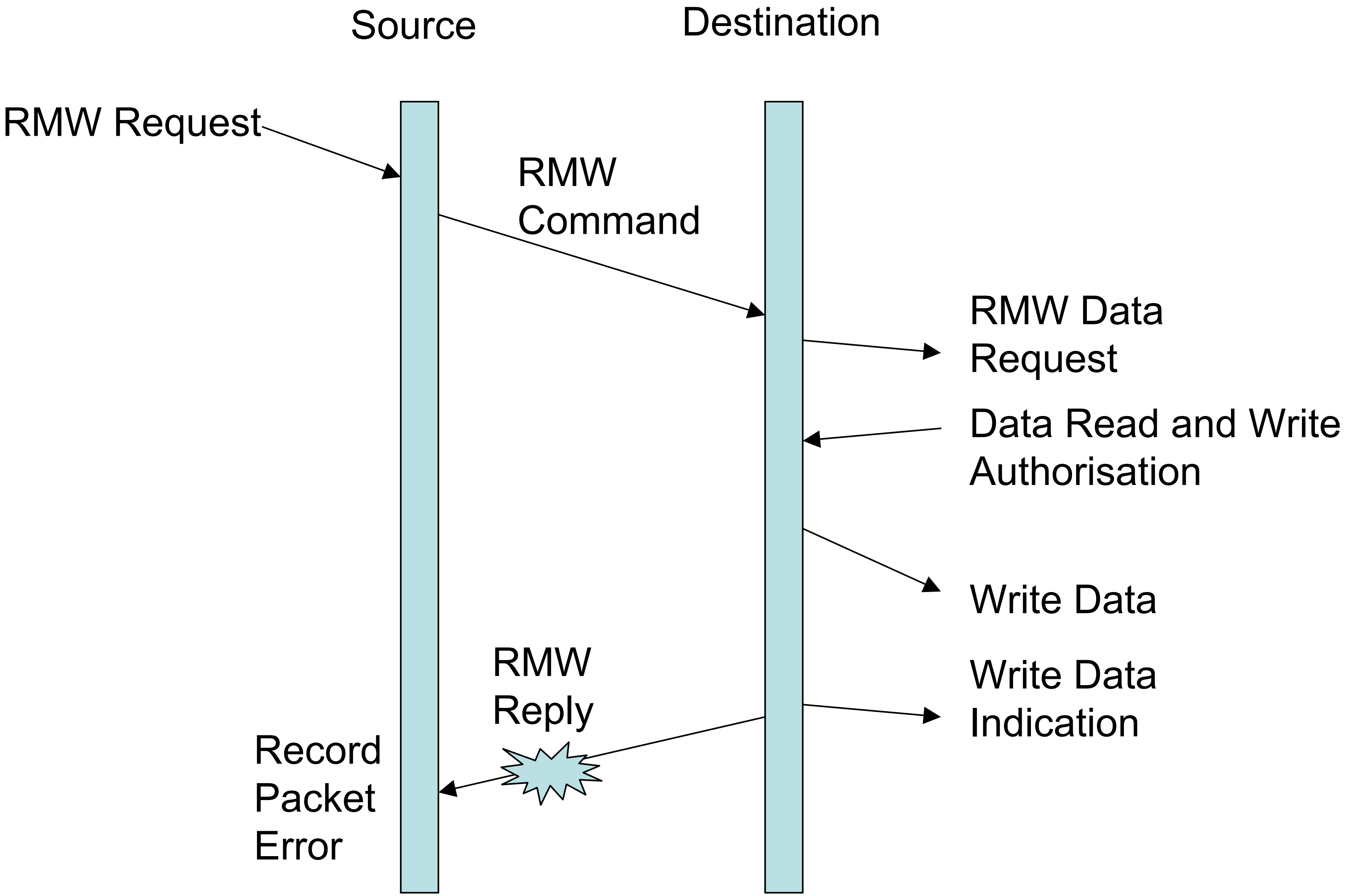
RMW Data Error Reply

RMW Data Failure

RMW Authorisation Rejection



RMW Reply Error



Read-Modify-Write

- If data length is zero no data will be read or written
- Data length of zero can be used for testing whether a command is acceptable by a unit.

Read-Modify-Write Parameters

- Destination address
- Source address
- Transaction identifier
- Destination device type
- RMW command
- Memory address
- Data length
- Data
- Mask

Error Codes

Error Code	Error	Error Description
000	Command executed successfully	
001	General error code	The detected error does not fit into the other error cases or the node does not support further distinction between the error
002	RMAP command not supported by node	The header checksum was decoded correctly but the command byte is not accepted by the node
003	RMAP device type not supported by node	The header checksum was decoded correctly but the device type does not match that of the destination node.
004	Invalid data checksum	Error in the checksum of the data field

Error Codes

Error Code	Error	Error Description
005	Early EOP	EOP marker detected before the end of the data.
006	Late EOP	EOP marker detected beyond the expected end of the data.
007	Verify buffer overrun	The verify before write bit of the command was set so that the data field was buffered in order verify the data checksum before transferring the data to destination memory. The data field was longer than could fit inside the verify buffer resulting in a buffer overrun.
008	Authorisation failure	The destination user application did not authorise the requested operation
009	RMW data length error	The data in a RMW command does not match the data length field or is invalid (01h, 03h, 05h, 07h or >08h).

Device Types

- 00h is a general device type
- 01h is a router
- 02h is a sensor
- 03h is an actuator
- 04h is a mass memory unit
- 05h is a processing element
- 06h is network controller
- A node may be able to act as more than one device type.
- E.g. processing node may be able to act as a processing element and a mass memory unit.
- General device type is used when SpaceWire device does not fit into any other defined device categories.

Partial Implementation of RMAP

- Partial implementations are permitted
- E.g
  - Support of write and read but not RMW commands
  - Support of 32-bit data lengths only
- If destination receives command it does not support
- Or command with options not supported
- It refuses to authorise the command
- Command is not executed
- If reply requested then it will contain Authorisation Failure error code

RMAP update

- Comments from
  - Martin Suess ESA
  - Wahida Gasti ESA
  - Rafaelle Vittuli ESA
  - Luca Tunesi ESA
  - Torbjorn Hult Saab Ericsson
- Corrections to document
- Changes considered and adopted as appropriate