SpaceWire-D

Steve Parkes, Albert Ferrer
University of Dundee

Stuart Mills, Chris McClements, Alex Mason,
Paul McKechnie, Pete Scott, Bruce Yu,
STAR-Dundee Ltd

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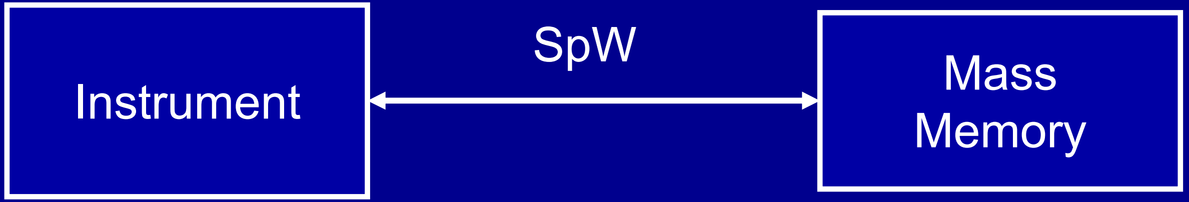
New SpaceWire Protocols

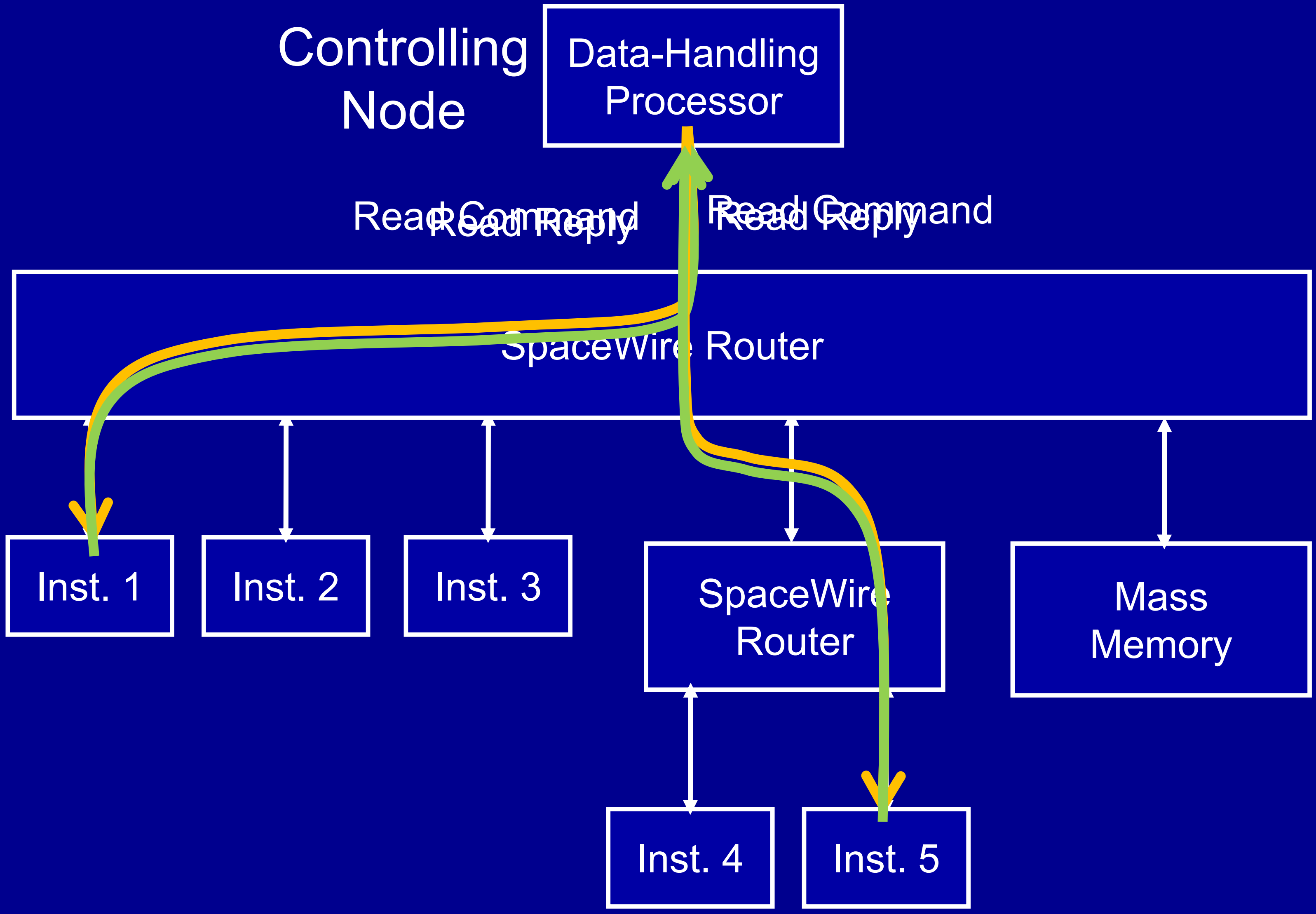
- SpaceWire Protocol ID
  - ECSS-E-ST-50-51C
  - Identifies packets as belonging to a particular protocol
- Remote Memory Access Protocol (RMAP)
  - ECSS-E-ST-50-52C
  - Read from and write to memory in a remote node over a SpaceWire network
  - Ideal for configuration, control, housekeeping and data collection
  - Already being used on several missions
- CCSDS Packet Transfer Protocol
  - ECSS-E-ST-50-53C
  - Transfers CCSDS Space Packets over SpaceWire

Deterministic SpaceWire (SpW-D)

- SpaceWire for control applications
- Determinism is essential
  - Determinism means
    - Predictable
    - Delivery within time constraints
  - Constrained Architecture
  - Time-slicing
- Single SpaceWire link is deterministic



Determinism with Constrained Architecture



Controlling Node

Data-Handling Processor

Read Command

Read Reply

Read Command

Read Reply

SpaceWire Router

Inst. 1

Inst. 2

Inst. 3

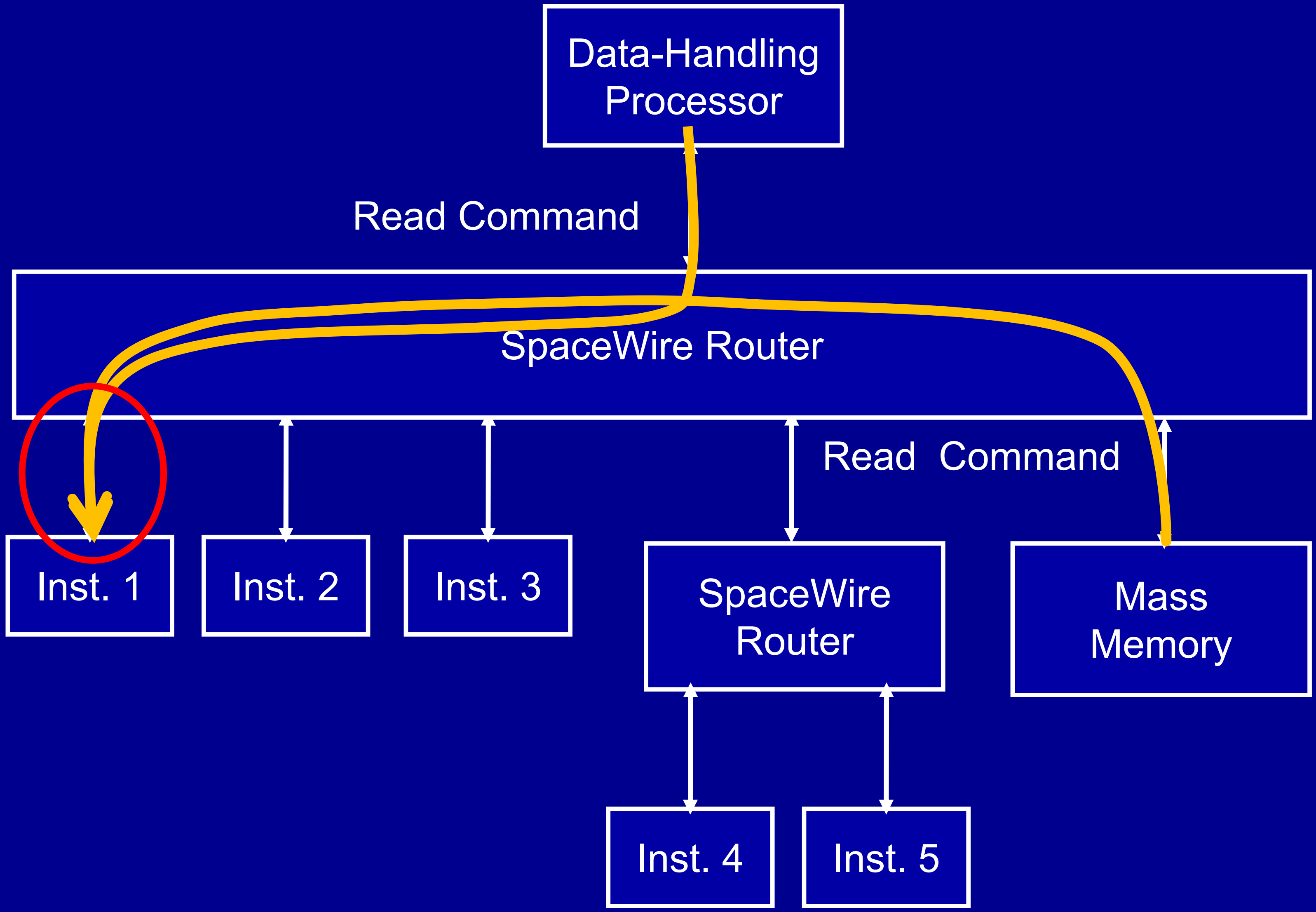
SpaceWire Router

Mass Memory

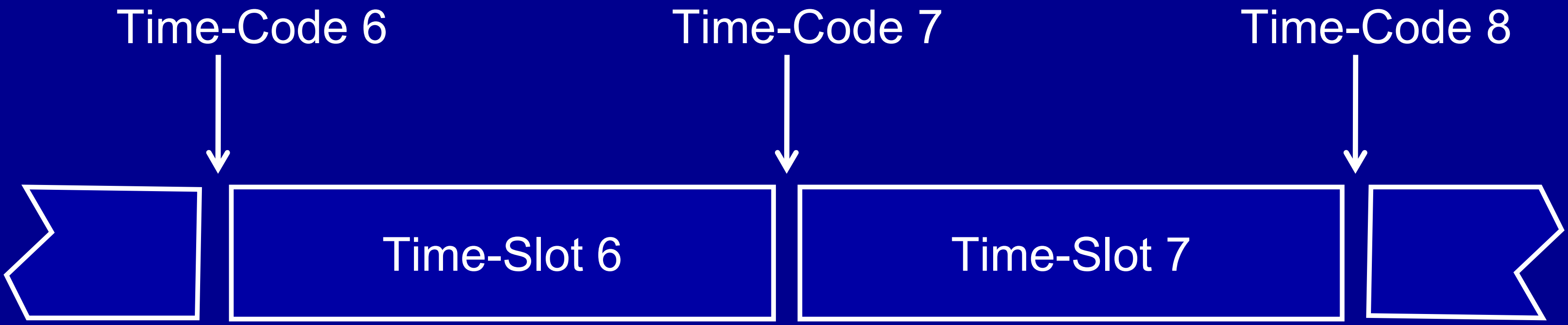
Inst. 4

Inst. 5

Problem with Multiple Masters

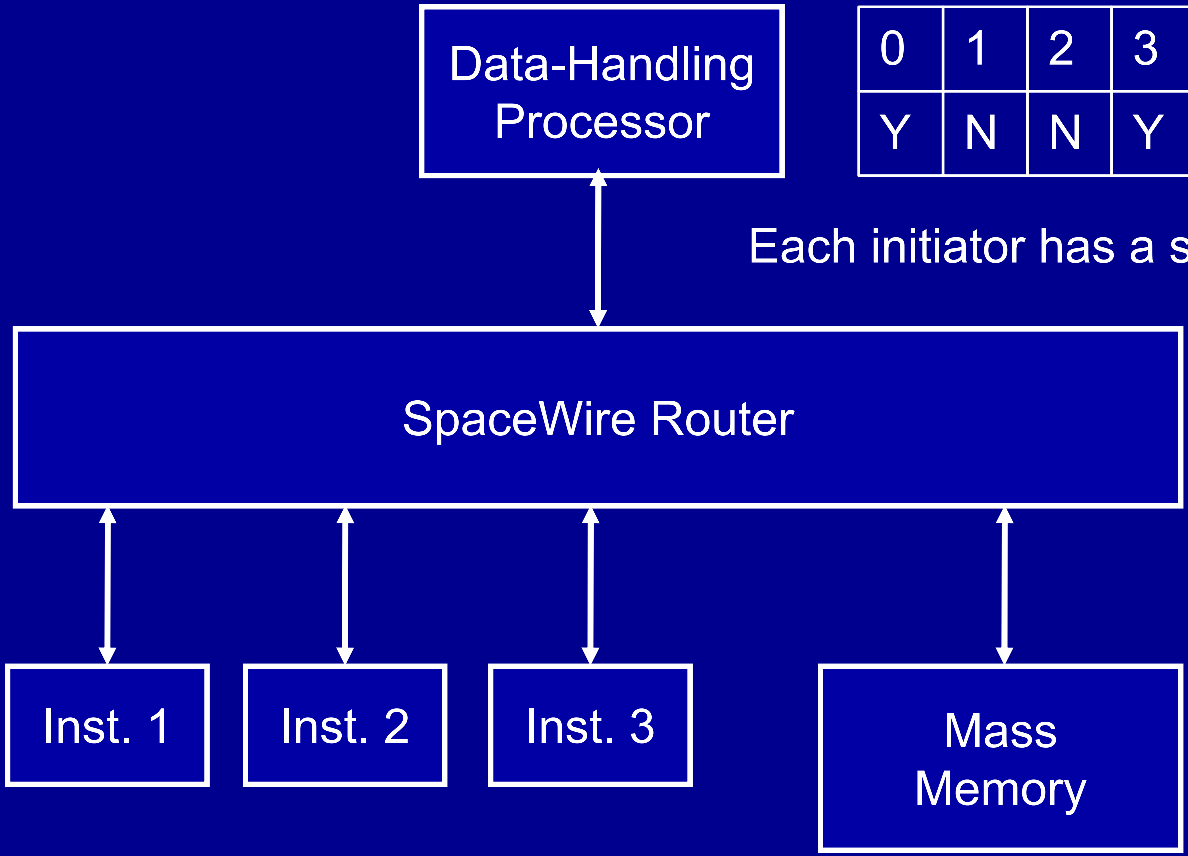


Determinism with Time-Slots



- Time-codes used to define time-slots
- Time-slot has same number as time-code that starts the time-slot
- 64 time-slots

Determinism with Time-Slots



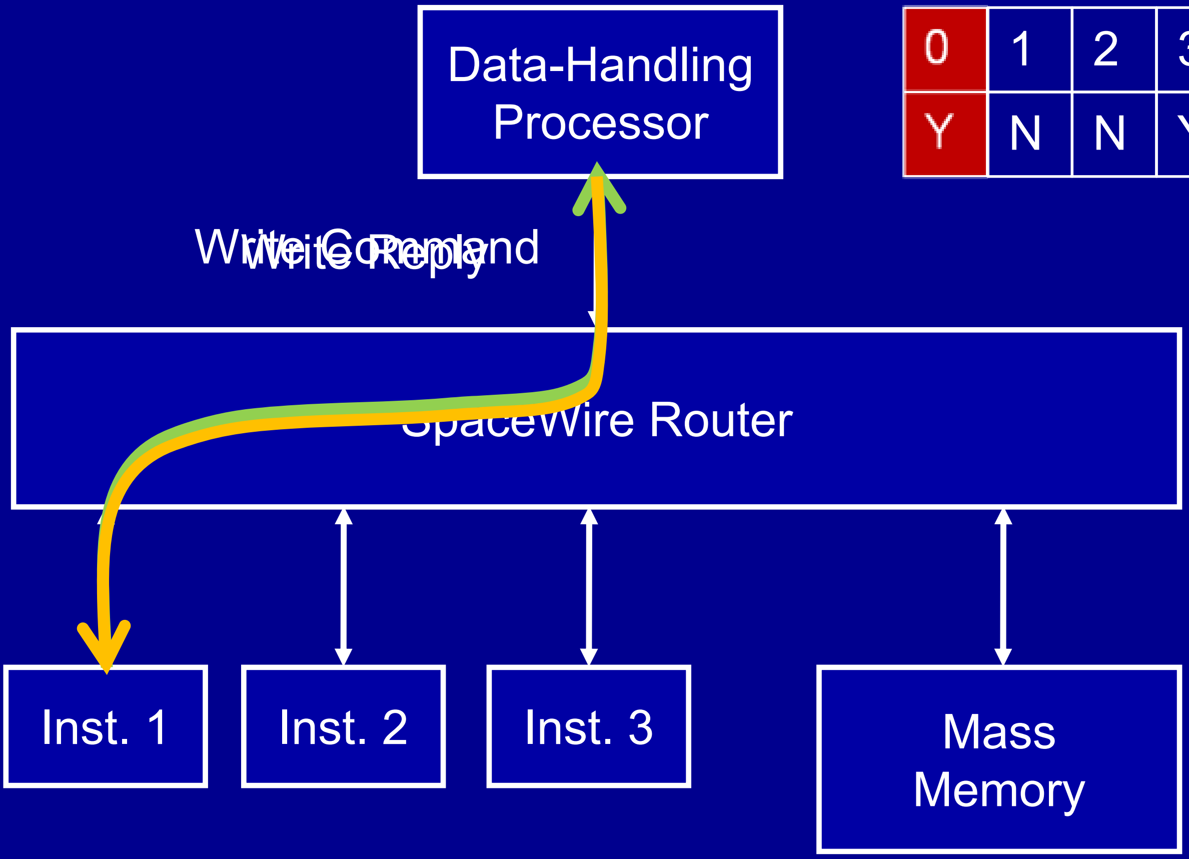
0	1	2	3	4	...
Y	N	N	Y	N	...

Each initiator has a schedule table

0	1	2	3	4	...
N	Y	Y	N	N	...

Specifies in which time-slots an initiator is allowed to initiate an RMAP command

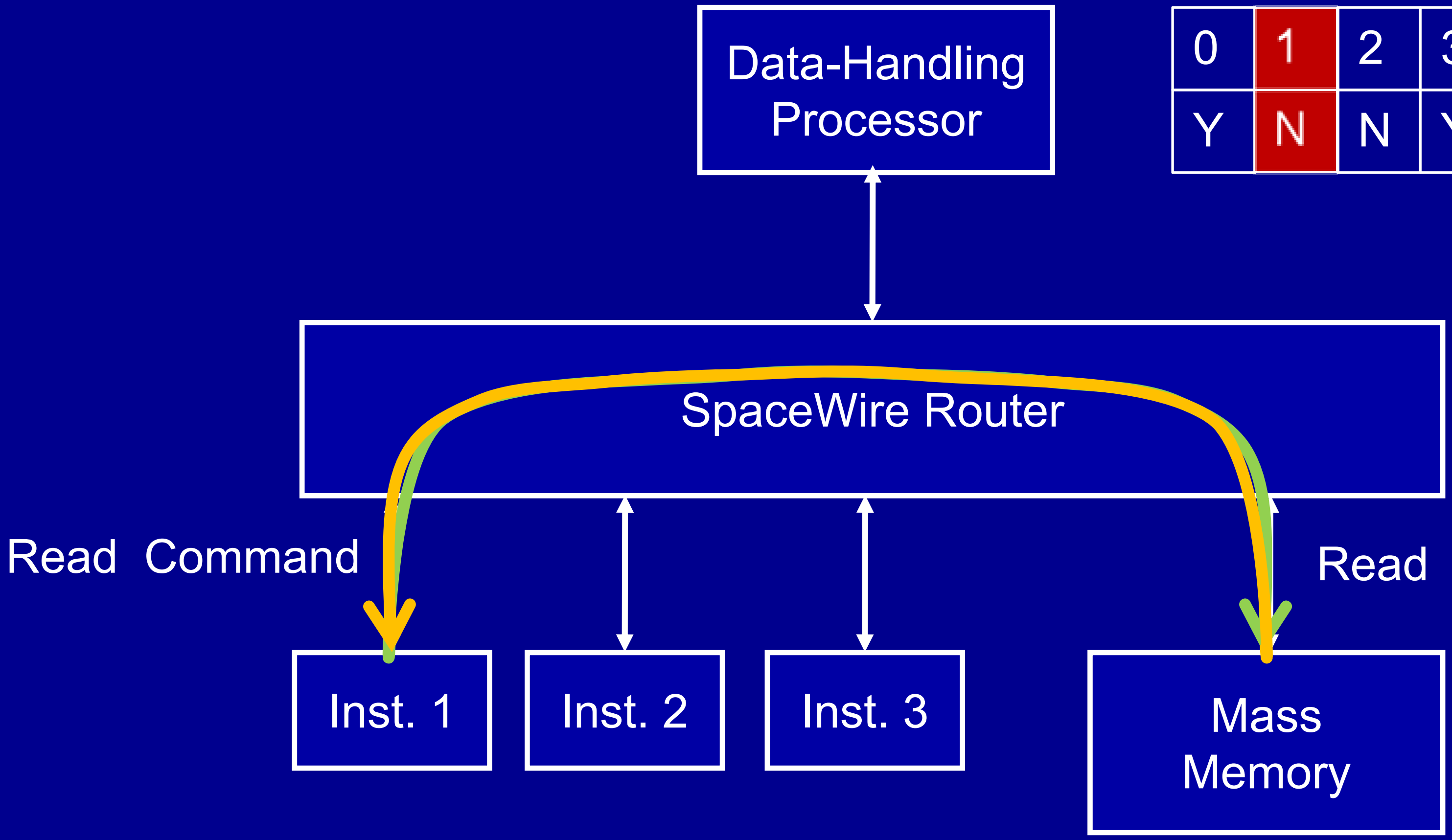
Time-Slot 0



0	1	2	3	4	...
Y	N	N	Y	N	...

0	1	2	3	4	...
N	Y	Y	N	N	...

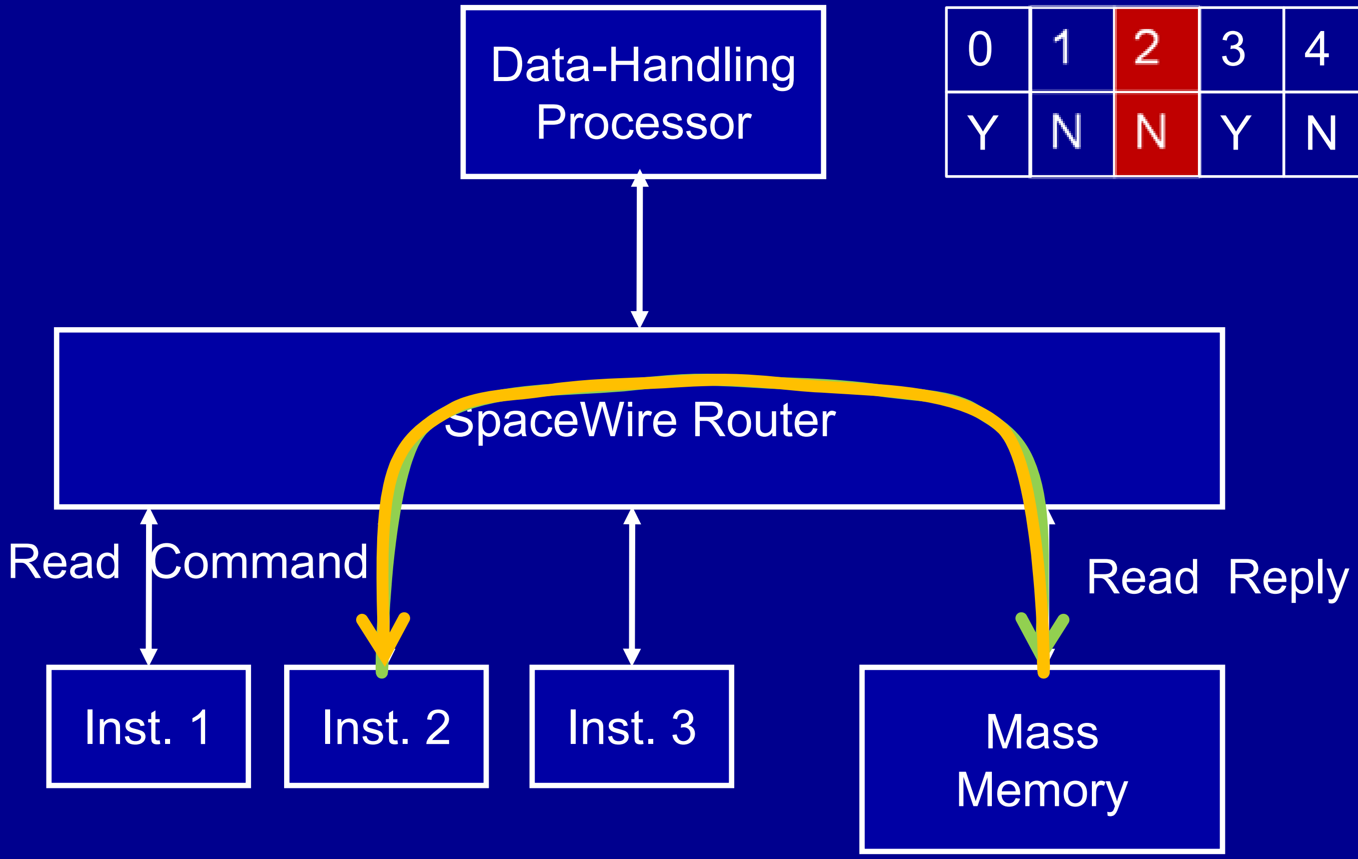
Time-Slot 1



0	1	2	3	4	...
Y	N	N	Y	N	...

0	1	2	3	4	...
N	Y	Y	N	N	...

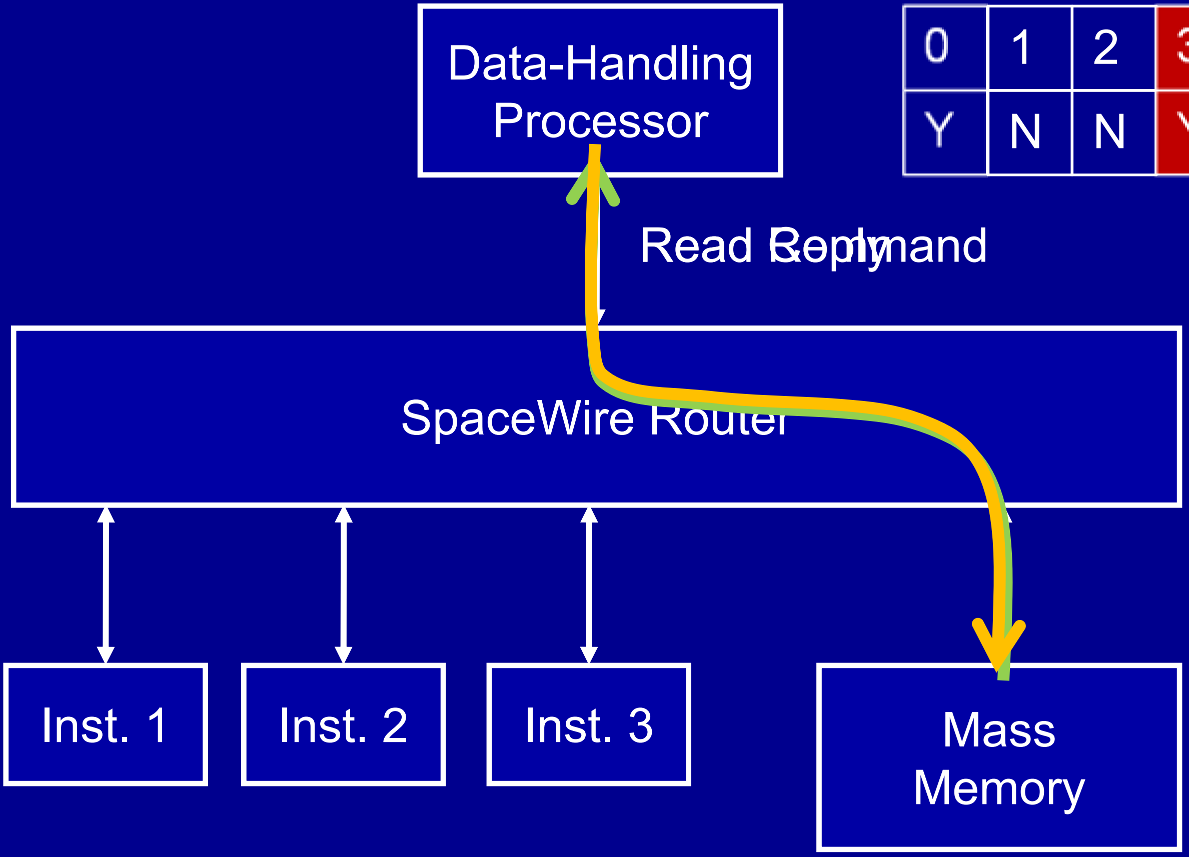
Time-Slot 2



0	1	2	3	4	...
Y	N	N	Y	N	...

0	1	2	3	4	...
N	Y	Y	N	N	...

Time-Slot 3



Data-Handling Processor

Read Command

Read Reply

SpaceWire Router

Inst. 1

Inst. 2

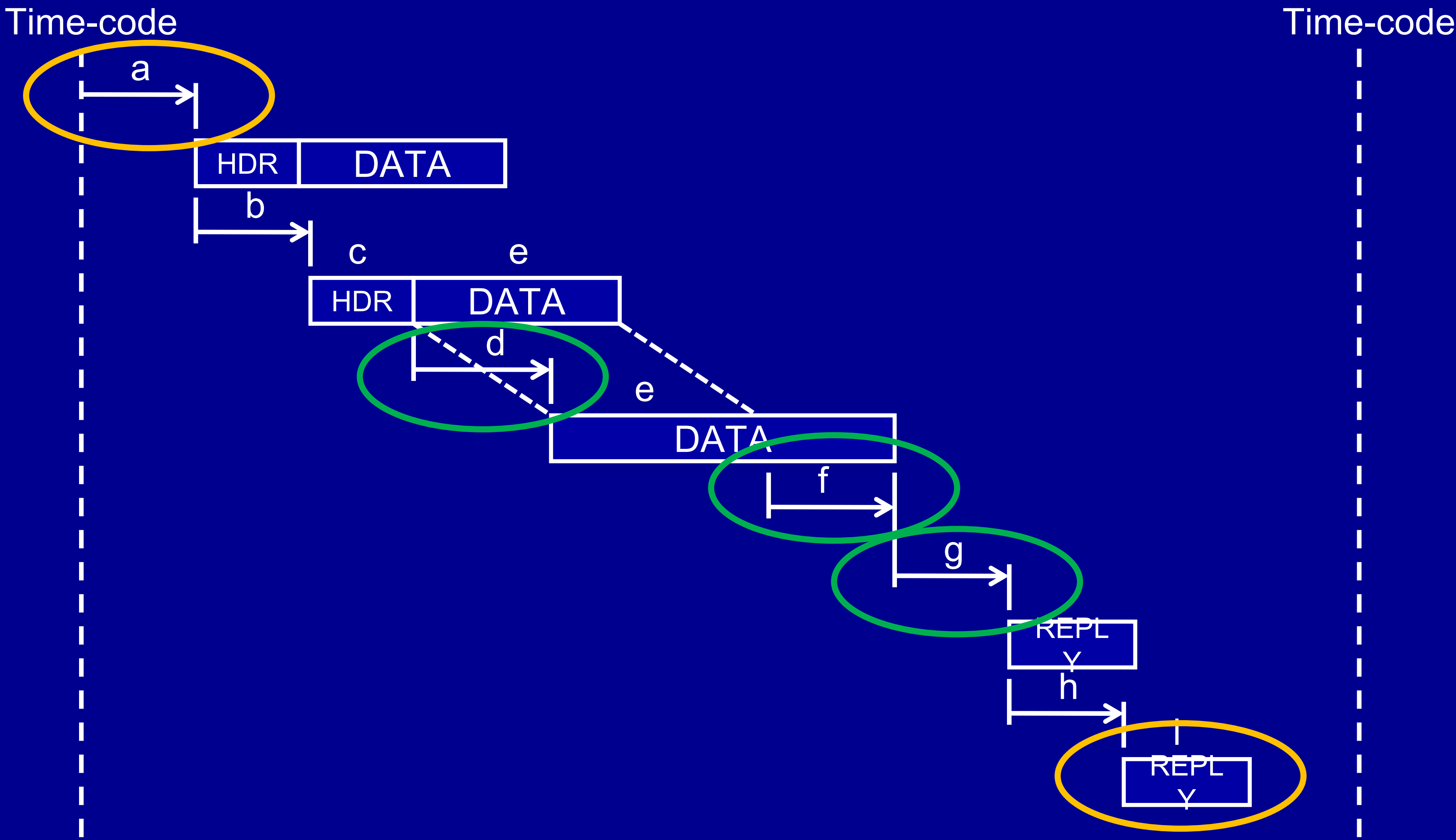
Inst. 3

Mass Memory

0	1	2	3	4	...
Y	N	N	Y	N	...

0	1	2	3	4	...
N	Y	Y	N	N	...

SpW-D Performance



Initiator Constraints

- Max data in RMAP read or write is limited
- Must respond to time-code quickly
  - Time-code to send RMAP command < 5 µs (a)
- Must handle reply in a timely fashion

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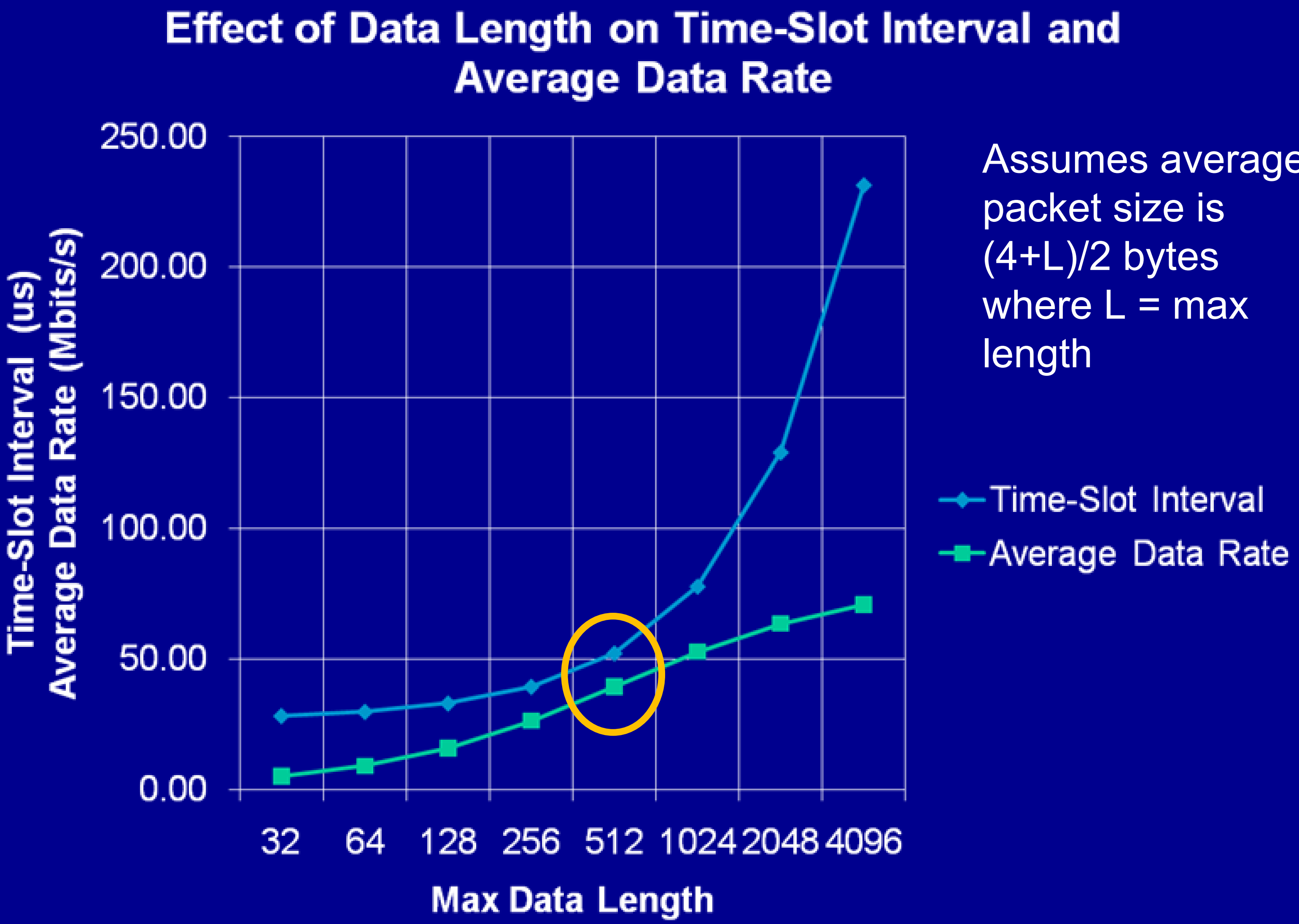
Target Constraints

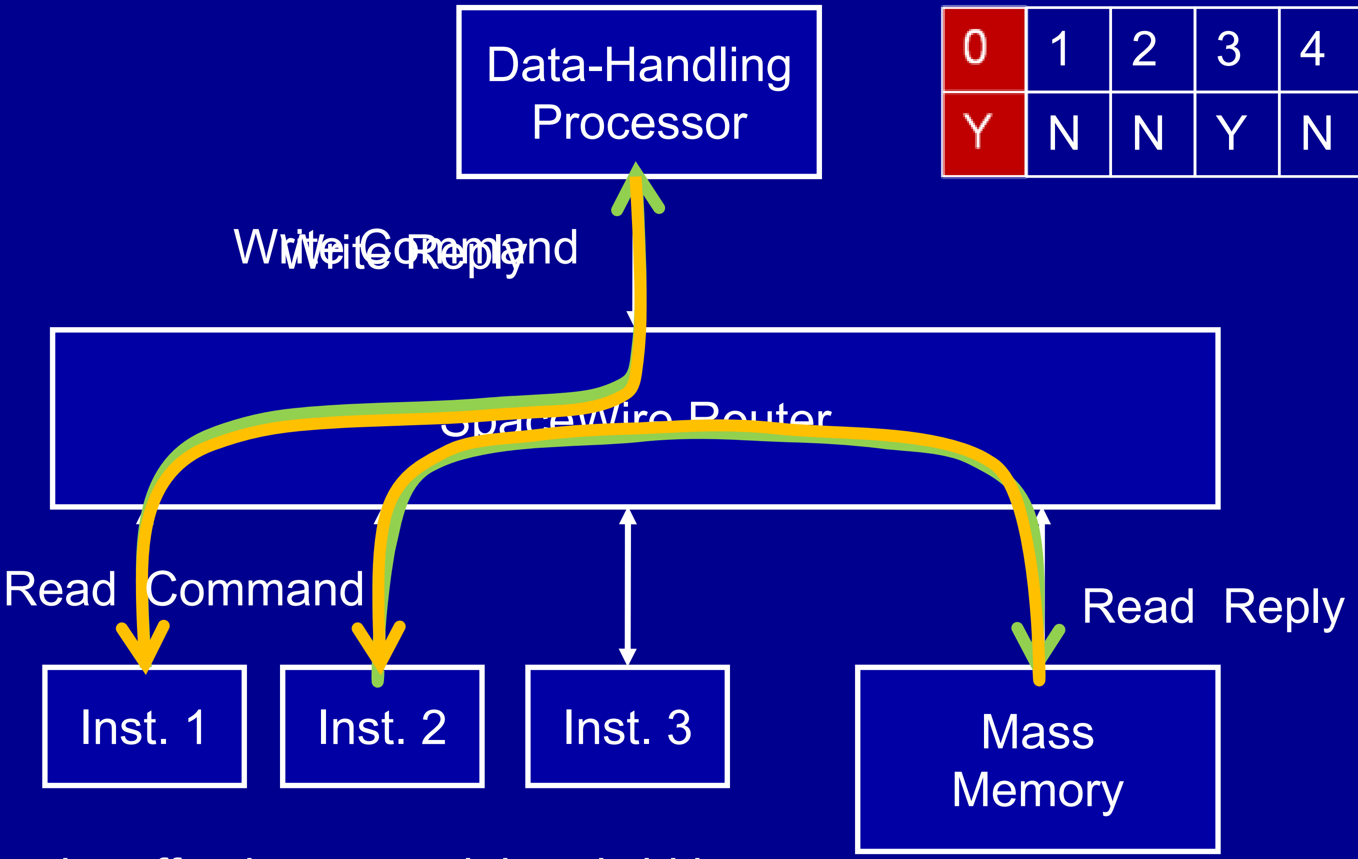
- No modifications to RMAP target
- Must respond to RMAP command quickly
  - End of header to authorisation: < 5 µs (d)
  - Read or Write at least as fast as SpaceWire link can handle data 20 Mbytes/s
  - Read or Write latency: < 5 µs (f)
  - Create reply: < 5 µs (g)
- Can simply state that
  - Target must respond to an RMAP command within
  - 15 µs + time to transfer the data (at full SpW link speed)

SpW-D Performance



Assumes average packet size is (4+L)/2 bytes where L = max length

Concurrent Data Transfer



0	1	2	3	4	...
Y	N	N	Y	N	...

Doubles the effective network bandwidth

Time and Space Partitioning of network
Time: using time-slots
Space: using different links

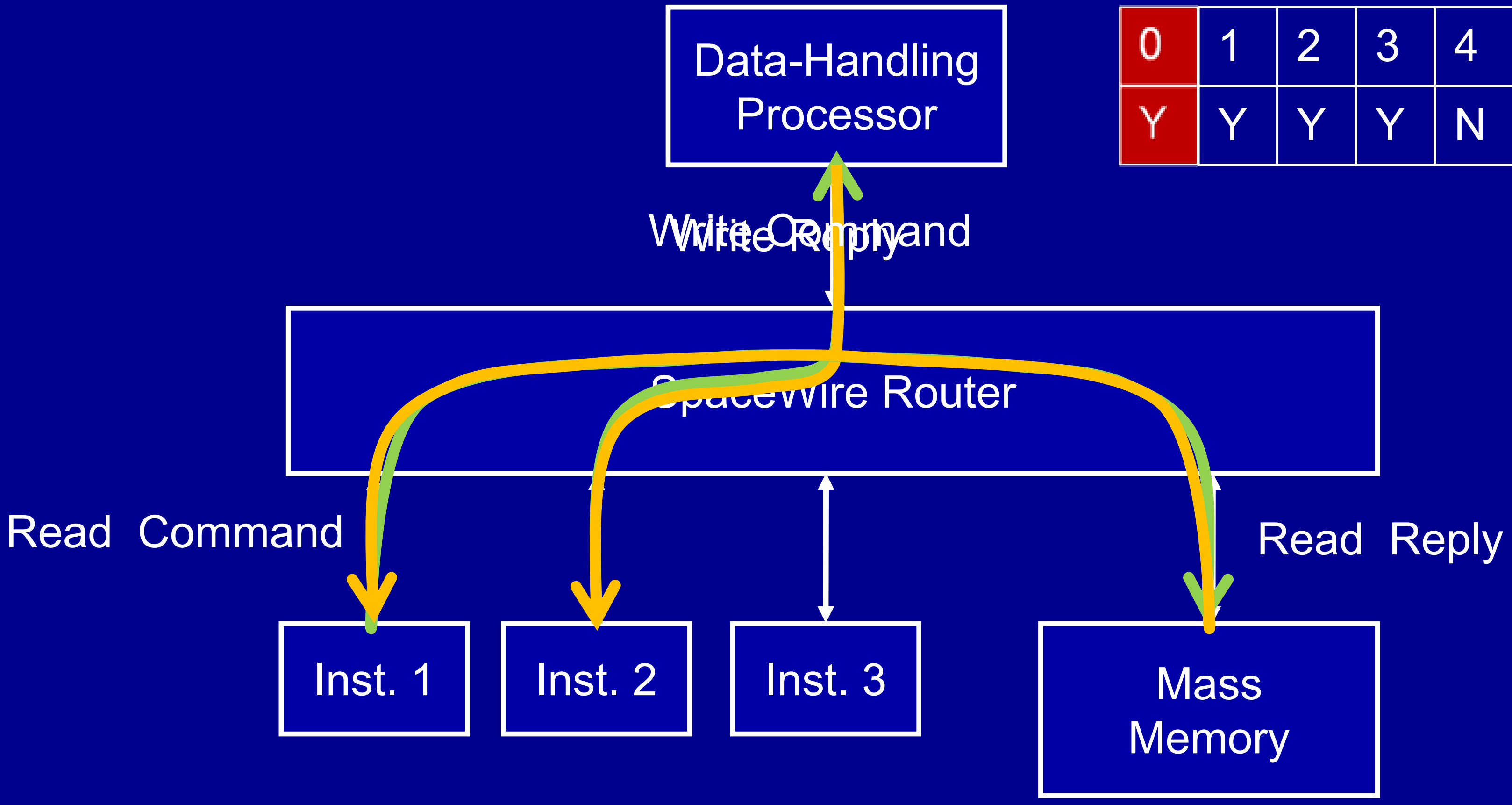
0	1	2	3	4	...
Y	Y	Y	N	N	...

Multi-Slot Data Transfer

- For large data transfers
- Allow RMAP transaction to run over many slots

Time Slot	1	2	3	4	5	6	7
Processor	45	89	87	48	45	96	87
Mass Memory	89	63			48	87	96

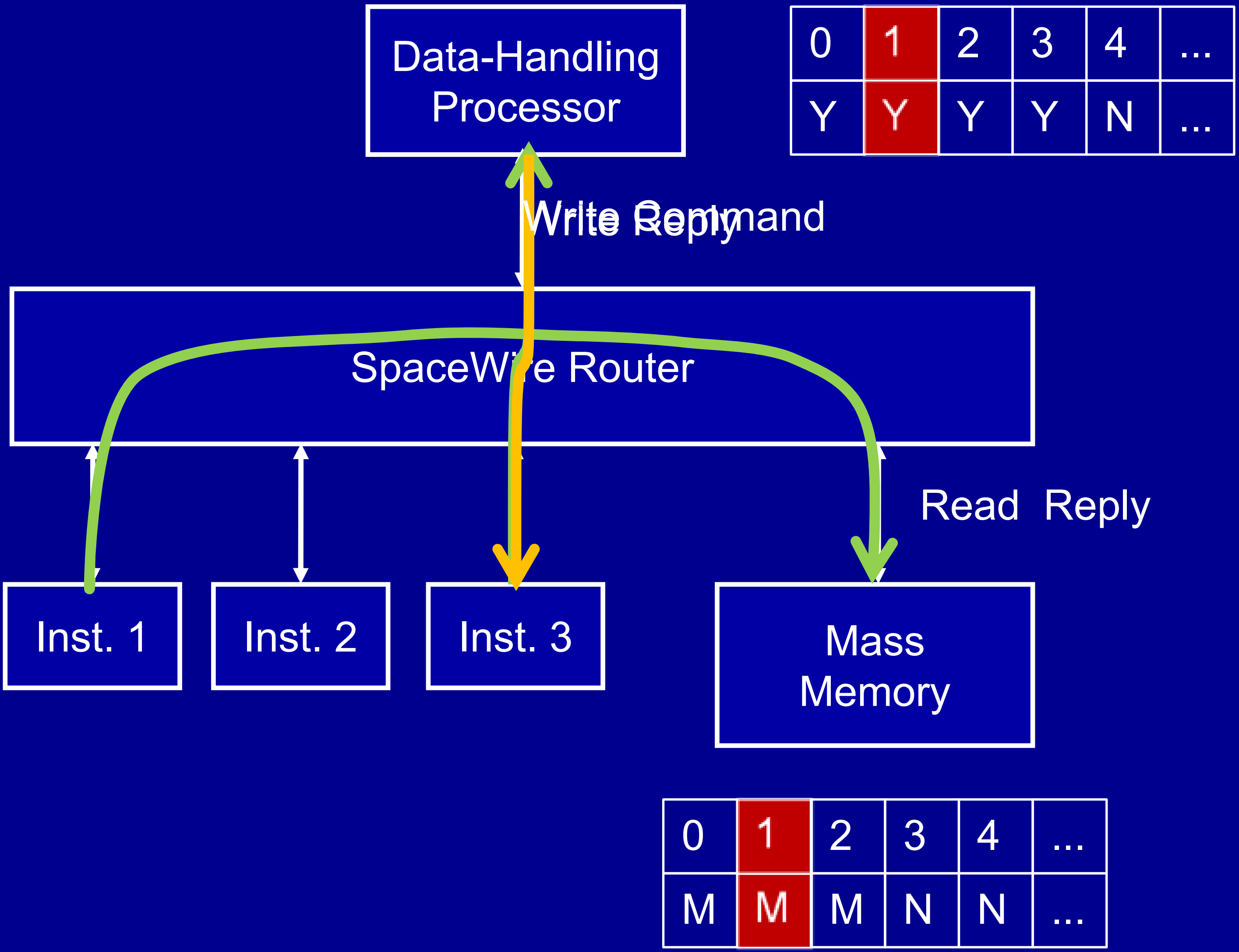
Multi-Slot Data Transfer:Time-Slot 0



0	1	2	3	4	...
Y	Y	Y	Y	N	...

0	1	2	3	4	...
M	M	M	N	N	...

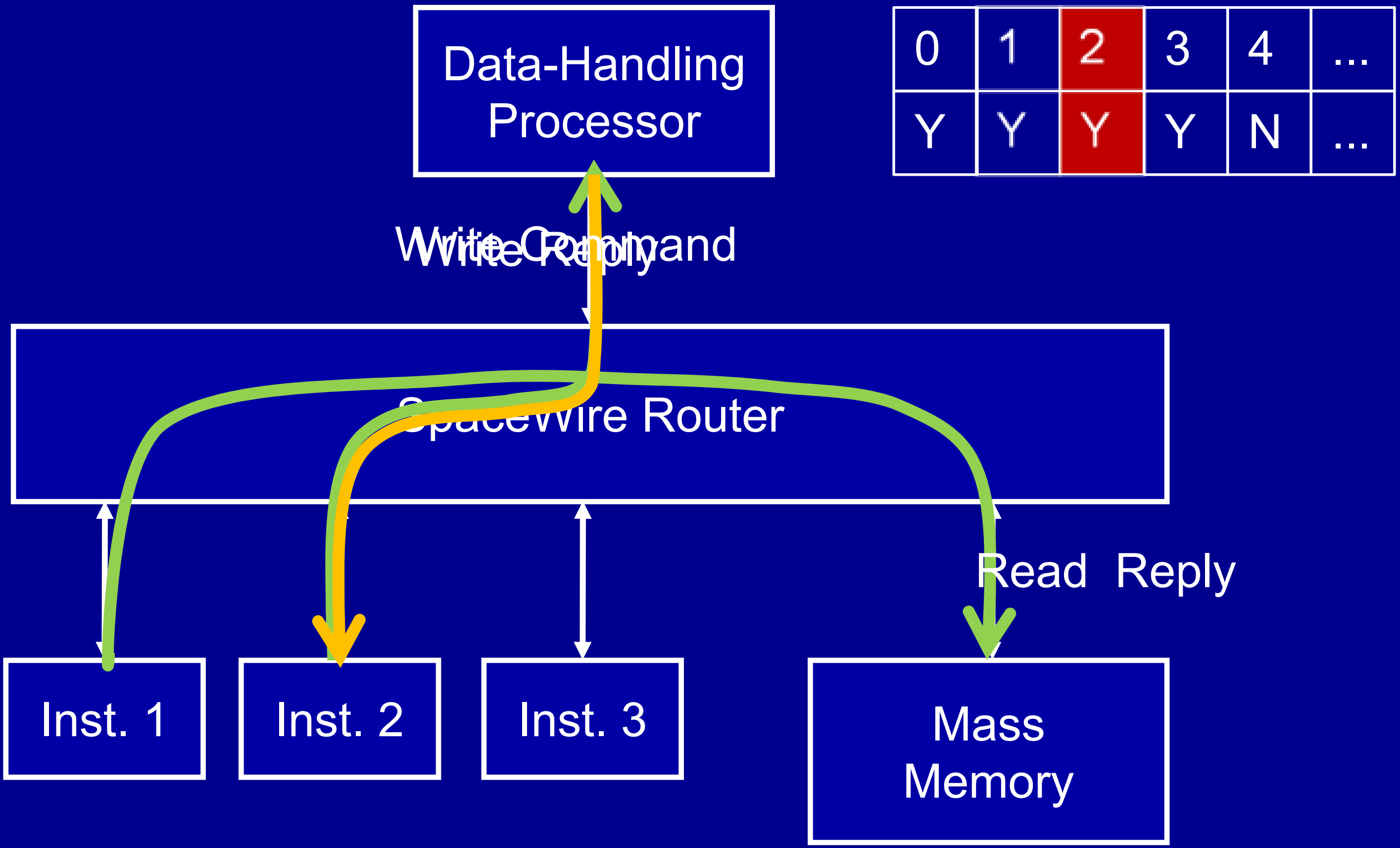
Multi-Slot Data Transfer: Time-Slot 1



0	1	2	3	4	...
Y	Y	Y	Y	N	...

0	1	2	3	4	...
M	M	M	N	N	...

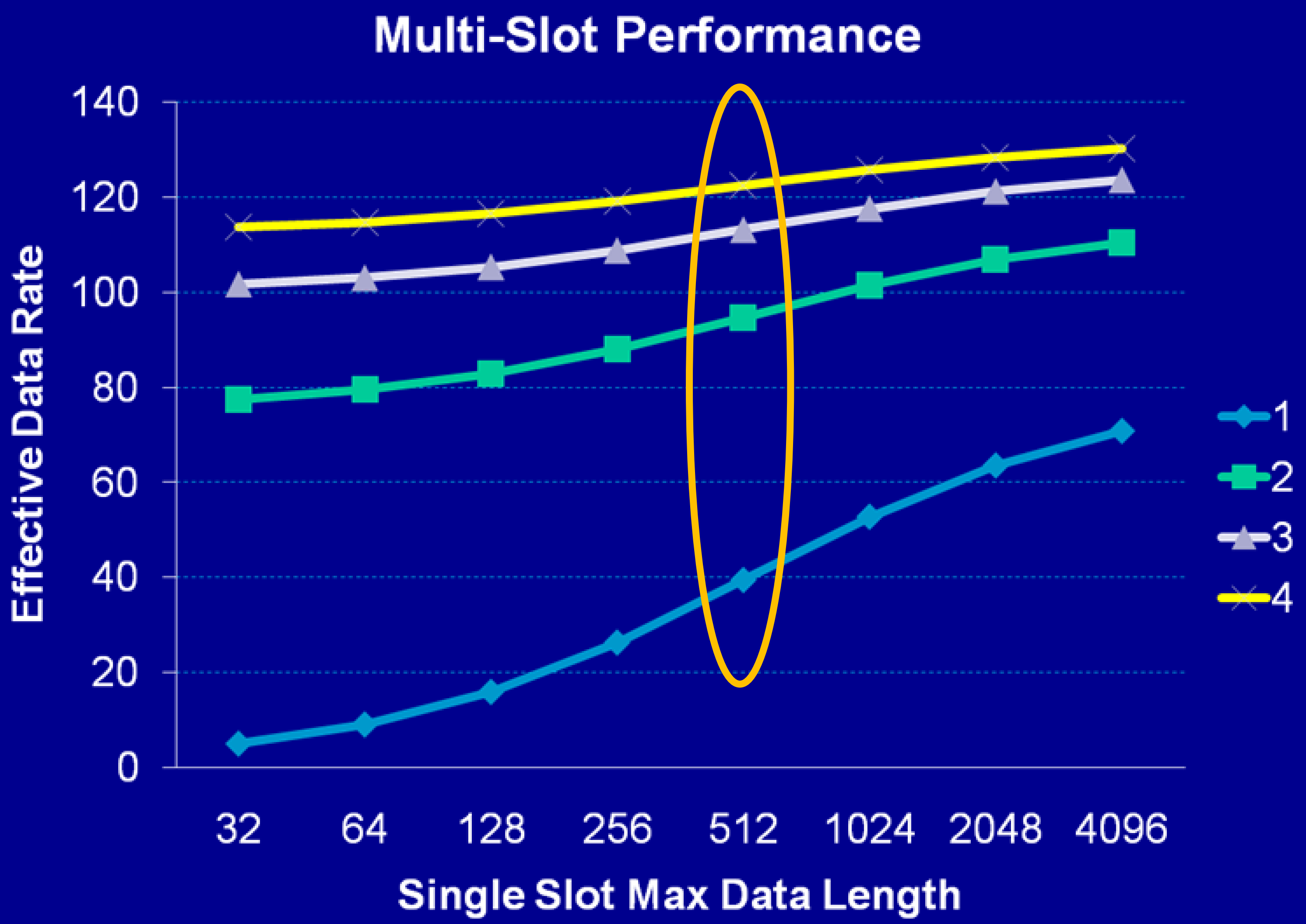
Multi-Slot Data Transfer: Time-Slot 2



0	1	2	3	4	...
Y	Y	Y	Y	N	...

0	1	2	3	4	...
M	M	M	N	N	...

Multi-Slot Performance



SpaceWire-D

- Built on SpaceWire and RMAP standards
- Uses time-codes to produce time-slots
- Schedules communication in time-slots
- Uses RMAP transactions
- Can support FDIR
- Simple constraints:
  - RMAP target
    - Speed of response to RMAP command
  - RMAP initiator
    - Speed of response to time-code
    - Limit to size of RMAP data field
- Very simple to implement

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Discussion

- *It is easy to make things complicated and difficult to keep them simple* ☺
- *The simpler something is the easier it is to check that it works properly* ☺ ☺

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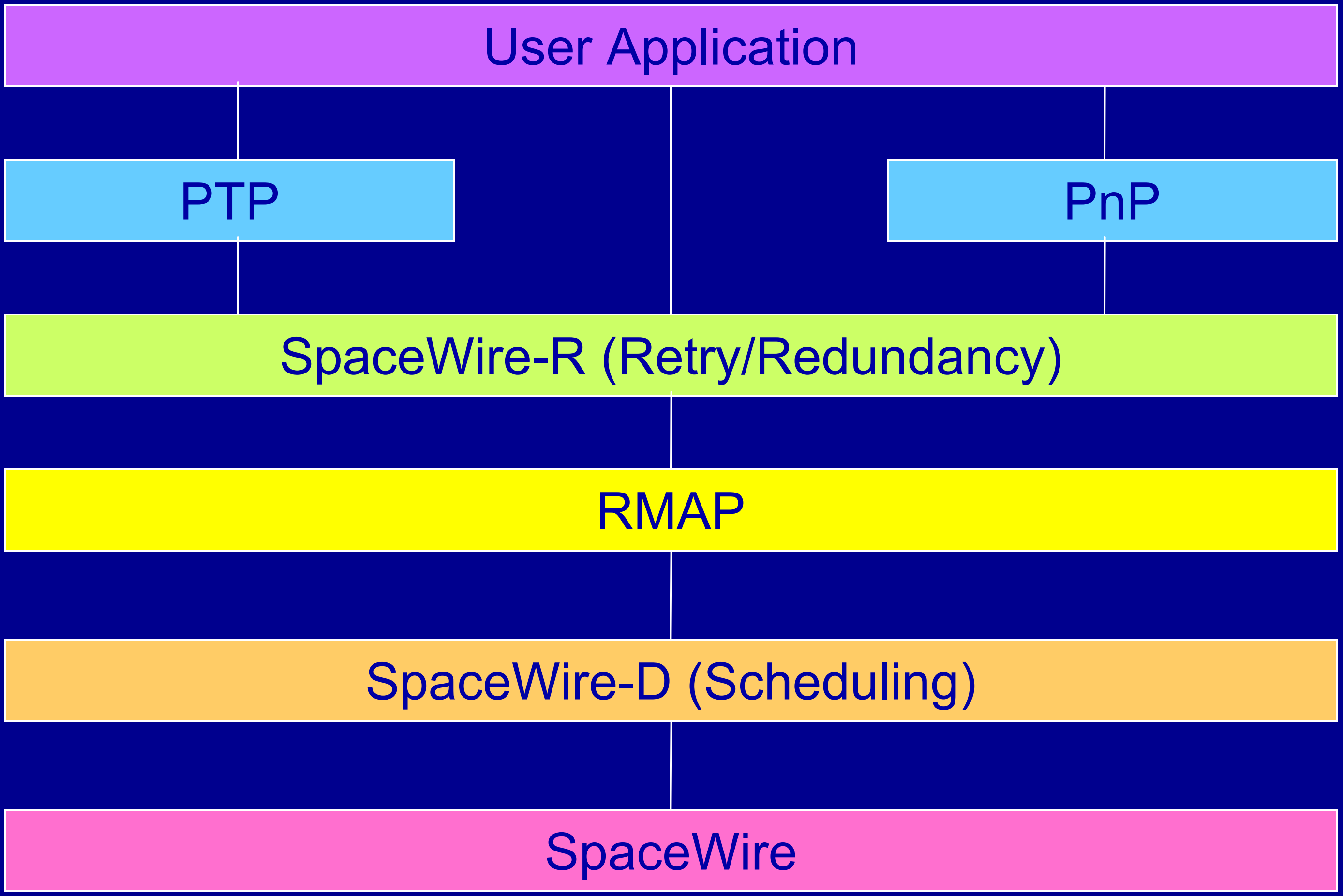
Discussion

- Key Principles
  - Simplicity
  - RMAP target unchanged
    - Provided it meets some (reasonable) performance criteria
  - FDIR more important than throughput

Discussion

- Is everyone happy with
  - Simple, concurrent and multi-slot scheduling?
- Multiple transactions in a single time-slot?
- Who specifies time-slot duration, data size, etc
  - The standard or the system engineer?
- Segmentation
  - Responsibility of application or standard?
  - Only modify the initiator?
- Retry and redundancy
  - Should this be included in the protocol stack?
- FDIR
  - How important is this?

SpW-D Protocol Stack



User Application

PTP

PnP

SpaceWire-R (Retry/Redundancy)

RMAP

SpaceWire-D (Scheduling)

SpaceWire

Discussion

- Is everyone happy with
  - Simple, concurrent and multi-slot scheduling?

Discussion

- Multiple transactions in a single time-slot?

Discussion

- Who specifies time-slot duration, data size, etc
  - The standard or the system engineer?

Discussion

- Segmentation
  - Responsibility of application or standard?
  - Only modify the initiator?

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Discussion

- Retry and redundancy
  - Should this be included in the protocol stack?

Discussion

- FDIR
  - How important is FDIR?

Things to be considered

- Amount of data in RMAP transaction?
  - Currently 512 bytes

Things to be considered

- Duration of time-slot?
  - Currently 50 usec
  - Request for epoch of 1/64 second
    - Makes a time-slot 15.6 ms
    - Not very timely but may be adequated

Things to be considered

- Allow various specific time-slot durations?
- Allow system engineer to determine time-slot duration?

Things to be considered

- Data rates on links
  - Normally should all be the same
  - Do we allow links of slower data rate to be supported
  - May be reducing the size of packet that can be transferred?
  - Or using multiple time-slots?

Things to be considered

- Key thing is what do we specify/constrain in the standard?
- We could leave it open and have devices specify key parameters e.g.
  - Speed of response of target device
  - Data rate supported

Things to be considered

- Multiple transactions in one time-slot?
  - Would add flexibility to SpW-D
  - But make FDIR much more difficult
  - Trade-off between flexibility/complexity vs FDIR

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Things to be considered

- Segmentation
  - Do we include segmentation of large RMAP transactions in the SpW-D protocol?
  - i.e. SpW-D able to perform any required RMAP transaction.

Things to be considered

- Retry and Redundancy
  - Do we include this in the protocol stack?
  - Along with FDIR mechanisms?

Things to be considered