SpaceWire CODEC Update

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Initial Validation

- Validation performed on the CODEC
  - CODEC RTL Verification Test-bench
    - Auto-check go-no-go VHDL Test-bench
    - Test cases derived from SpaceWire standard
    - Cross reference matrix with SpaceWire standard
  - Router Test-bench
    - VHDL Test-bench
    - Test cases derived from SpaceWire router specification

Data Characters

P	0	X	X	X	X	X	X	X	X
		0	1	2	3	4	5	6	7
		LSB							MSB

Data-Control Flag

Parity Bit
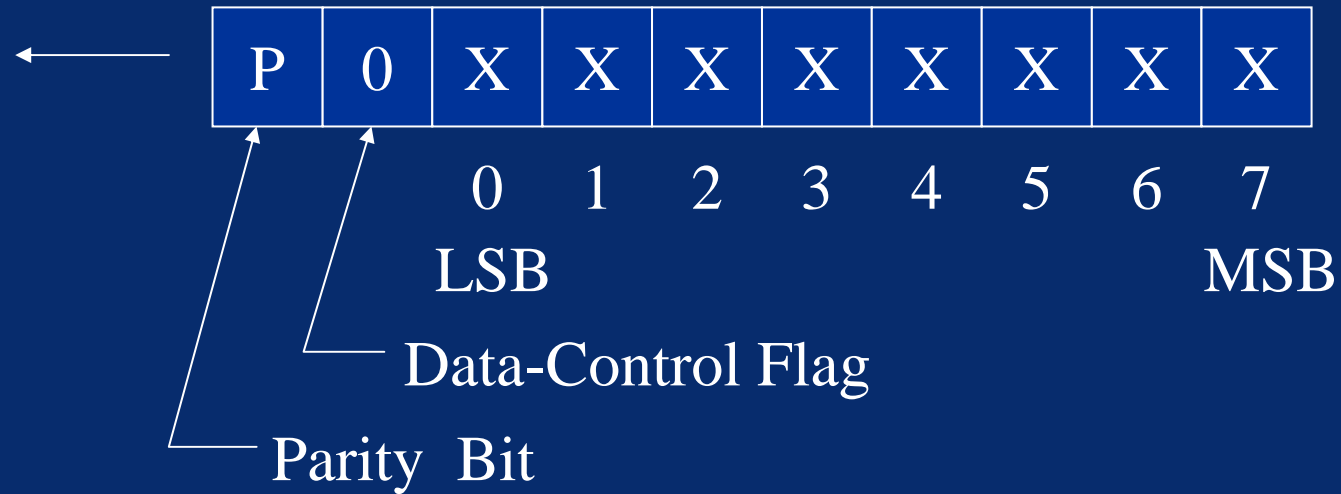
Control Characters

P	1	0	0	←	FCT	Flow Control Token
P	1	0	1	←	EOP	Normal End of Packet
P	1	1	0	←	EEP	Error End of Packet
P	1	1	1	←	ESC	Escape

Control Codes

ESC FCT

P | P | 1 | 1 | 1 | 0 | 1 | 0 | 0   NULL

P | P | 1 | 1 | 1 | 1 | 0 | T | T | T | T | T | T | T | T   Time-code

ESC   0 1 2 3 4 5 6 7

LSB   MSB
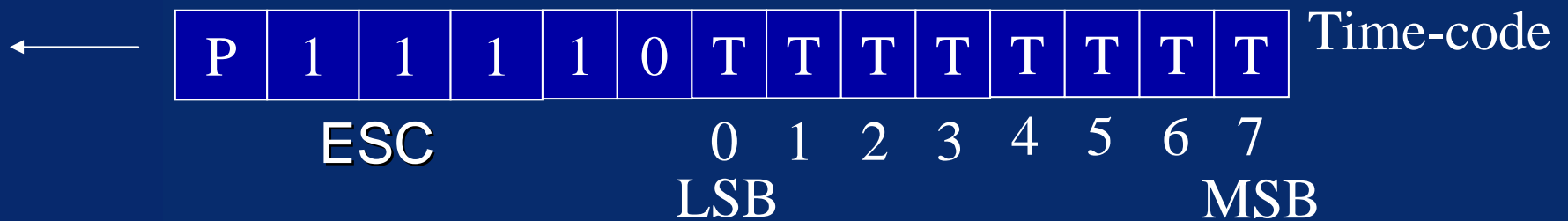
Problems found with CODEC

- Empty packets (double EOP/EEP)
  - Only first EOP/EEP taken into account
  - By receive credit counter
- Problem detected using SpaceWire Conformance Tester
- If many double or multiple EOP/EEPs received then link will run out of credit
- Link then stops
- Must be restarted by Link Disable or Link Reset

Problems found with CODEC

Data	Data	Data	EOP	Data	Data	Data	EOP

TX 12 11 10 9 8 7 6 5
RX 12 11 10 9 8 7 6 5

Data	Data	EOP	EOP	EOP		Data	EOP	EOP	EOP

TX 4   3   2   1   0   16 15 14 13 12
RX 4   3   2   1   0   16 15 14 13 12

Data	Data	EOP	EOP	EOP		Data	EOP	EOP	EOP

TX 4   3   2   1   0   8   7   6   5   4
RX 4   3   2   2   2   10 9   8   8   8

Note: Empty packets are not permitted by the SpaceWire standard

Solution to Problem

- Empty packet handling moved from receiver to receive credit counter
- Main problems to overcome:
  – Empty packets can arrive every four bits
  – At 200 Mbits/s credit counter must be updated at 50MHz
  – This poses a timing constraint on the system
- Novel approach to handling double EOP/EEP avoids this problem
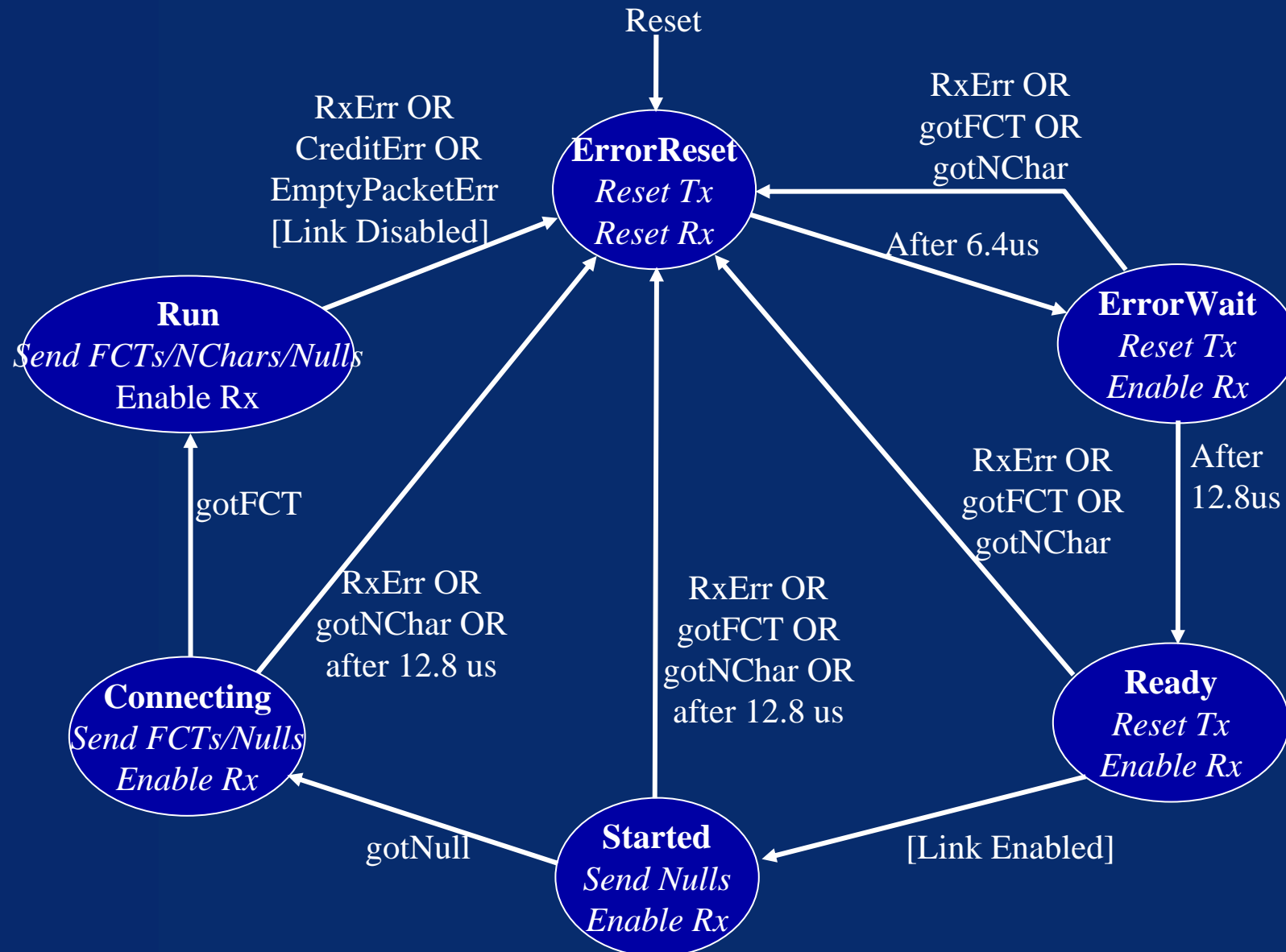 – Without performance or power disadvantage

Problems found with CODEC

- Link recovery timing on multiple cycles through Link Reset state
- First time round timing is correct
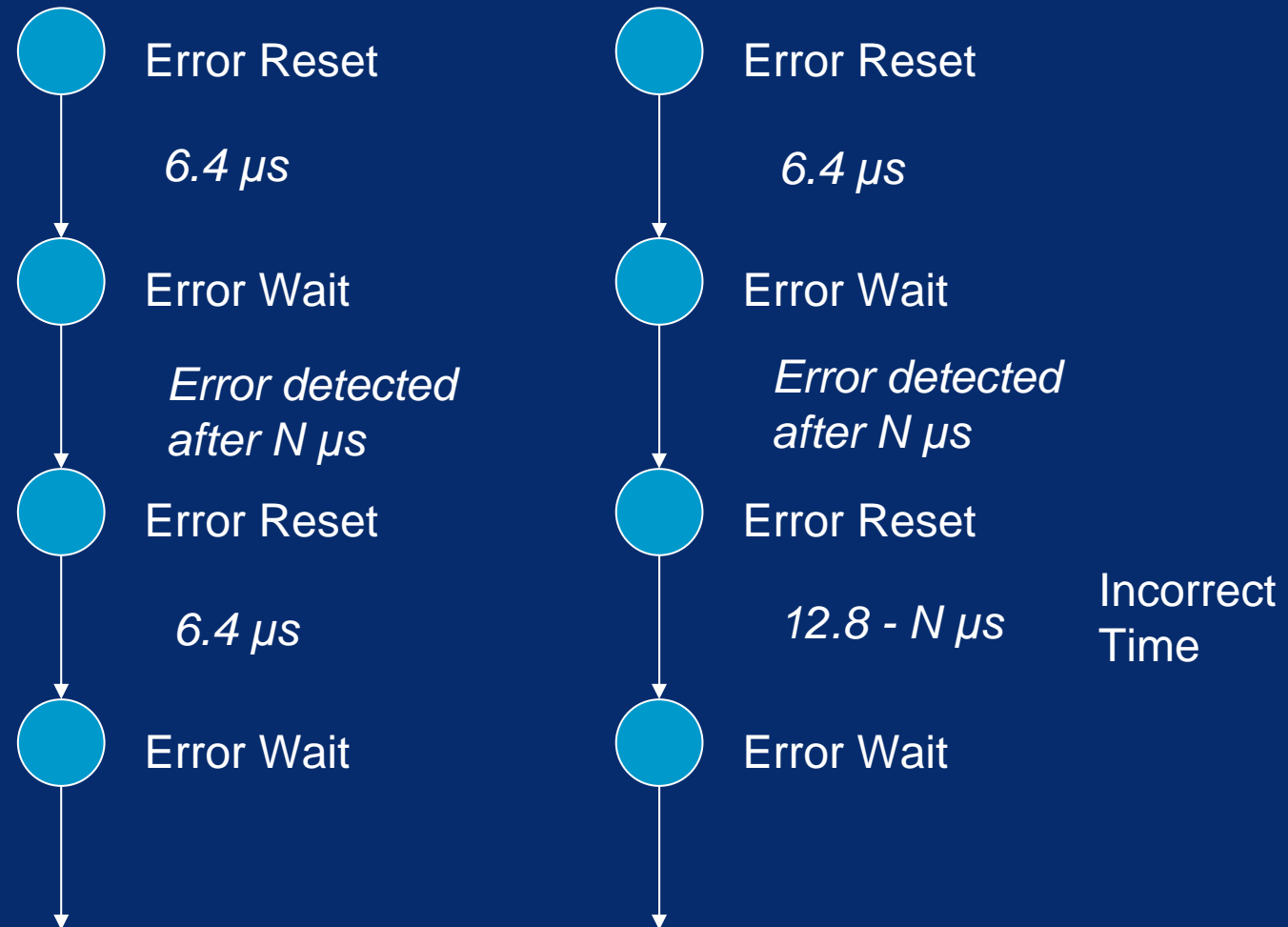- Problem detected by SpaceWire Conformance Tester

SpaceWire Link State Machine

Reset

ErrorReset
Reset Tx
Reset Rx

RxErr OR
CreditErr OR
EmptyPacketErr
[Link Disabled]

RxErr OR
gotFCT OR
gotNChar

After 6.4us

Run
Send FCTs/NChars/Nulls
Enable Rx

ErrorWait
Reset Tx
Enable Rx

After
12.8us

gotFCT

RxErr OR
gotNChar OR
after 12.8 us

RxErr OR
gotFCT OR
gotNChar OR
after 12.8 us

RxErr OR
gotFCT OR
gotNChar

Connecting
Send FCTs/Nulls
Enable Rx

Ready
Reset Tx
Enable Rx

gotNull

Started
Send Nulls
Enable Rx

[Link Enabled]

Problems found with CODEC

Error Reset

6.4 µs

Error Wait

Error detected after N µs

Error Reset

6.4 µs

Error Wait

Error Reset

6.4 µs

Error Wait

Error detected after N µs

Error Reset

12.8 - N µs

Error Wait

Incorrect Time

Solution to Problem

- Transition timer always reset on entry to ErrorReset state

Further Validation after Code Changes

- Updated test scripts to cover errors detected
- Empty packet test extended to cover complete set of empty packet sequences
  - Normal packet followed by EOP
  - Normal packet followed by EEP
  - EOP followed by EOP
  - EOP followed by EEP
  - EEP followed by EOP
  - EEP followed by EEP
- Number of empty packets input to receiver
  - Increased to more than maximum credit count
  - Receiver should not run out of credit

Other Testing

- **Currently being tested by**
  - ESTEC
  - Austrian Aerospace – within router design
  - STAR-Dundee – within SpaceWire development and test units.
- **Expect new CODEC code to be released by End November 2005.**