Improving Auto-Negotiation Efficiency

Page Extension for 802.3ap

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Problem Statement

Clause 28 and Clause 37 auto-negotiation were created at a time when only a few ability bits had to be transferred.

Usually a single negotiation page was needed.

Per page negotiation initialization time cost is high - about 1/4 s for Clause 28 and page payload is small - at most 10 bits per exchange plus an extra exchange for message code.

New physical layers require more bits to be exchanged.

Goal: Enhance auto-negotiation to complete negotiation in two to three page exchanges

- For Clause 28 the solution should also reduce time cost per page.
- For Clause 37 the solution should retain backwards compatibility.

Overview of Clause 28 solution

- **All SSP negotiation can be done with extended pages - therefore no selector bit is necessary.**
- **All pages will be 48 bits rather than 16 bits per page.**
- **The existing state machines will support this with some updates to variable definitions.**

Extended base page format

Flag are the RF, Ack and NP bits

- **Selector code field and flag bit positions from Base page encoding are retained to simplify transition.**
  - **They are aligned to fall into one MDI register access.**
- **A 32 bit payload (unformatted code field) is supported.**
  - **Payload aligned for 2 MDI register accesses**
- **Reserved bits could be used as additional payload bits. It may be wise to hold back on some for future flags or selector field extension.**

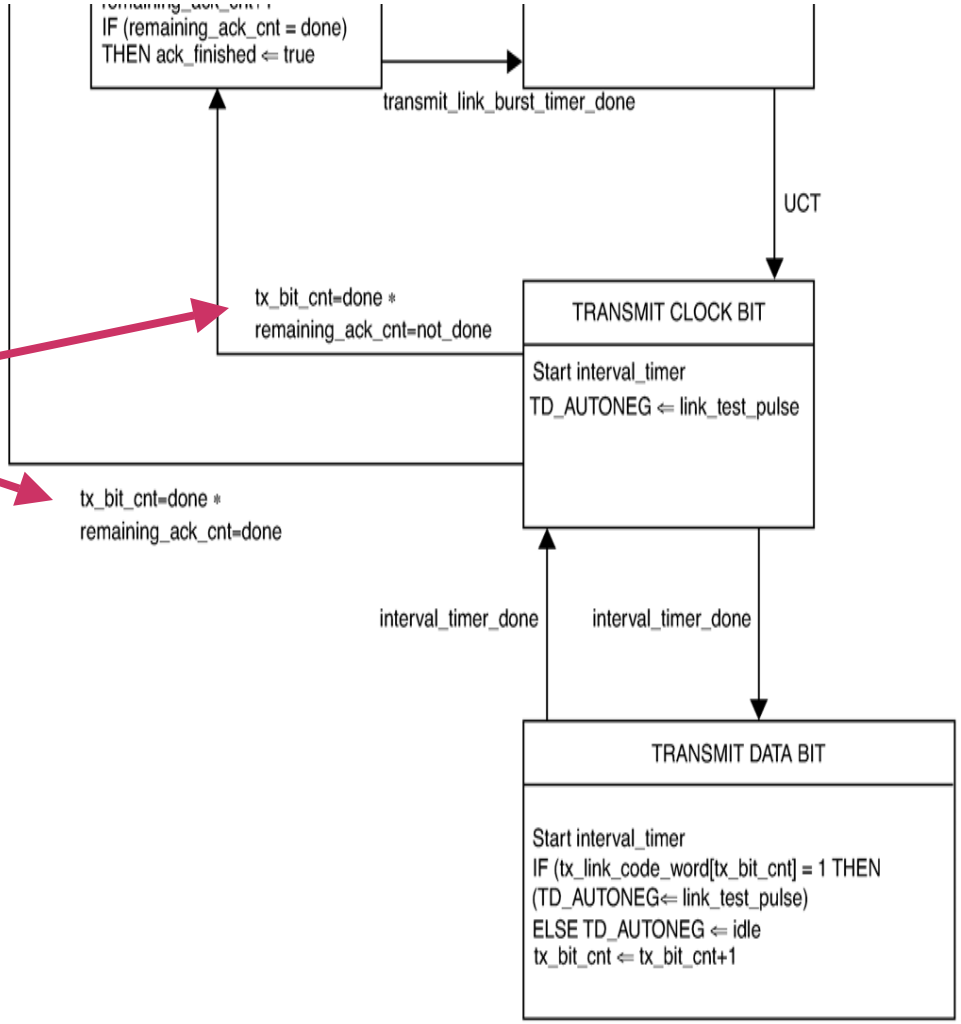
Extended next page format

Flag are the T, Ack2, MP, Ack and NP bits

- **Message code field and flag bit positions from legacy Next page message page encodings are retained to simplify transition.**
- **A 32 bit payload is supported.**

No effect on transmit state diagram

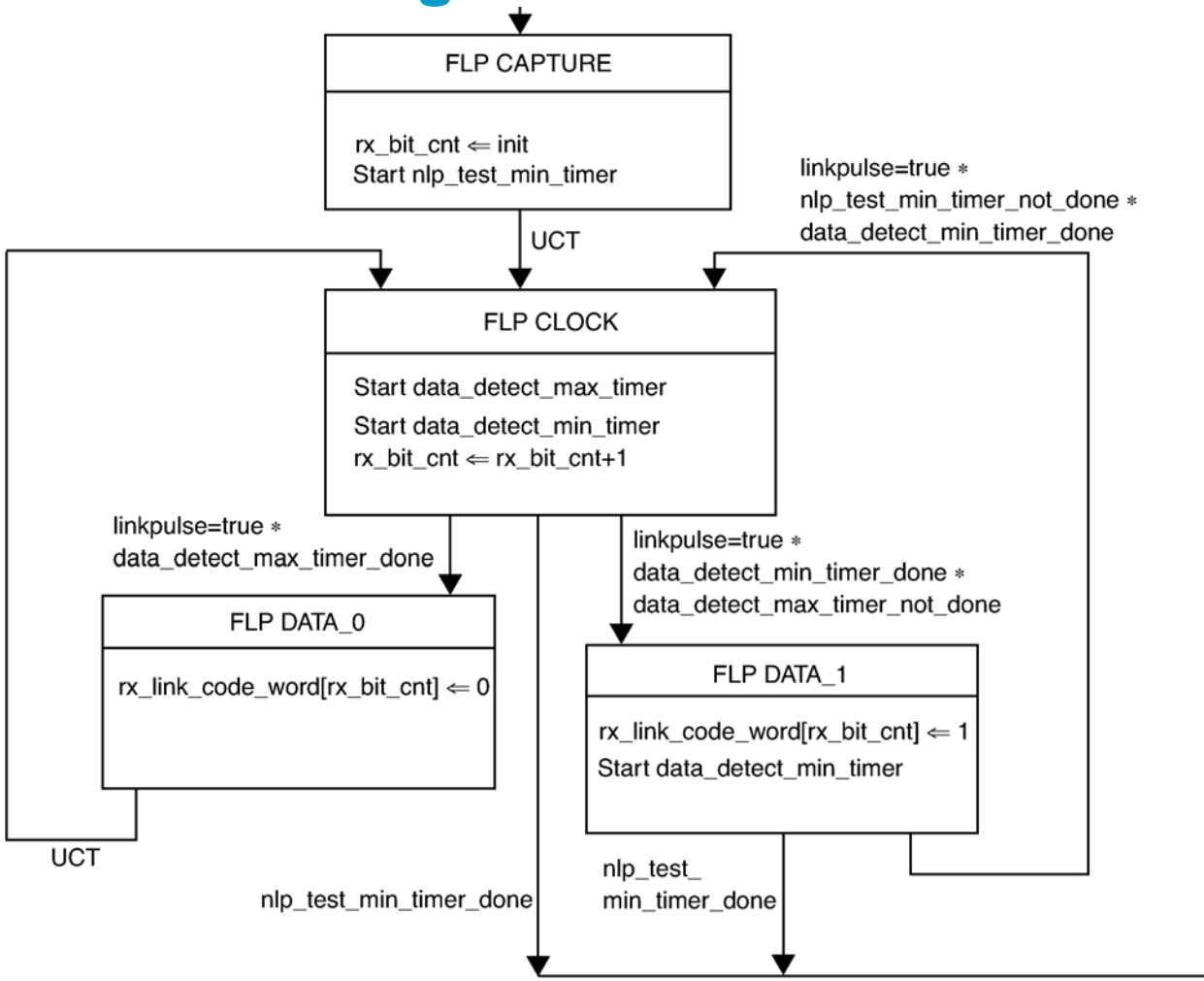
Note that tx_bit_cnt definition controls the number of bits sent.



No effect on receive state diagram

Note that rx_bit_cnt controls where bits are placed and the actual state diagram is independent of the number of bits received.

Total burst must be less than nlp_test_min_timer



Extended page burst length effect

- 48 bits at 125 us per bit (the time between clocks) require 6 ms to complete.
- Existing nlp_test_min_timer range is 5 to 7 ms.
- The smallest change fix is to require a range of 6.5 to 7 ms
- An alternative would be to reduce the values of all the pulse separation timers for SSP AN.

Other possible efficiency improvements.

- The original timers in auto-negotiation have very loose tolerances to allow for analog implementations (e.g. one-shots)
- FLP Burst to Burst time is allowed to vary from 8 to 24 ms.
- Each page negotiation requires enough time that:
  - Side A receives 3 matching FLP bursts and sets the Ack bit
  - Side B receives 3 matching FLP bursts with the Ack bit set
- Therefore, a single page exchange can be longer than 144 ms with the maximum burst to burst time.
- Negotiation time could be reduced by requiring burst to burst time for 10GBASE-T to more tightly controlled
  - Propose 8 ms min to 8.5 ms max
  - Improves time for 6 bursts to 51 ms.
- But we can do better

Efficiency improvements - continued.

- Greater improvement can be made by shifting to a new set of timer values when extended page mode is operational.
- Pulse width is 100 ns
- Page exchange time would be improved from 144 ms to ~0.5 ms

	Old nominal value	Extended page value
Clock pulse to clock pulse	125 us	0.8 us
Clock pulse to data pulse	62.5 us	0.4 us
clock pulses in burst	17	49
Burst width	2 ms	40 us
FLP burst to FLP burst	8-24 ms	80 us

Changes to state diagram variables.

- rx_bit_cnt - This counter takes values up to 49 and does not increment beyond 49. It takes the value: not_done for 1 to 47 inclusive, done for values 48 and 49.
- tx_bit_cnt - This counter takes values up to 49. It takes the value not_done for values from 1 to 48, done for 49.
- timer variables - change the values in accordance with the chart on the prior page.

Clause 28 Summary

Small changes can allow significant reduction in auto-negotiation time.

These changes should be made:

- **Add extended page length**
- **Reduce timer values to speed page negotiation.**

Clause 37 Solution Overview

- **Retain existing page length for base page to provide backward compatibility.**
- **Use a reserved bit in the base page to advertise Extended next page ability.**
- **Make Extended next page ability mandatory for Backplane Ethernet PHYs.**
- **Define a method for using ordered sets to send Extended next pages**
- **When both sides advertise Extended next pages, 48-bit pages will be used for next page negotiation.**

Page formats

Base page: No change from Clause 37 other than the allocation of a bit for Extended next page ability

Extended next pages: Same format as proposed for Clause 28 solution.

Coding for extended next pages

- Current Clause 37 negotiation uses one /C/ ordered set per page alternating between /C1/ and /C2/
  - /C1/ is /K28.5/D21.5/Config_Reg
  - /C2/ is /K28.5/D2.2/Config_Reg
- Create an additional C ordered set, /C3/, using a different value of D for the second character.
- Send extended next pages alternating between
  - /C1/C3/C3/
  - /C2/C3/C3/
  - /C1/ and /C2/ carry the first 16 bits of the page, the two /C3/ ordered sets carry the remaining 32 bits.

State machine changes

- No new states and no changes to transitions are needed
- Add a variable for extended next page mode
- Add actions to ABILITY_DETECT and NEXT_PAGE_WAIT states to load the additional 32 bits into the Tx_Config_Reg when extended next page mode is true.
- Extend variable descriptions to cover the longer page length.

Clause 37 summary

Small changes can be made to allow extended next page length

- **reduces negotiation time and complexity.**

Retain 16-bit base page to support legacy 1GBASE-X Phys.

Use Extended next pages for remainder of negotiation.

Management registers for extended next page

Registers could be read like the multi-register counters.

- **Reading the first register latches the other two registers**
- **The safest method is to allocate four additional clause 45 registers**
  - **two for the additional 32-bits of transmitted page data**
  - **two for the additional 32-bits of received page data**
- **An alternative would be to return the values in 3 reads of the same register but there is a risk of getting out of sync.**

The first method is recommended.

Summary

Both Clause 28 and Clause 37 based auto-negotiation can support extended next page for better initialization efficiency.