802.3ap Auto-Negotiation
with Clause 28 State Machines

Presentation to

IEEE 802.3ap Task Force

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Contributors and Supporters

Contributors

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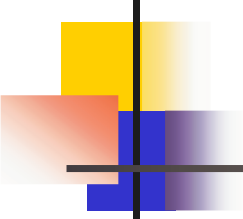Nitish Amin   Vitesse
Thomas Kirkegaard Jørgensen   Vitesse
Petre Popescu   Quake Tech
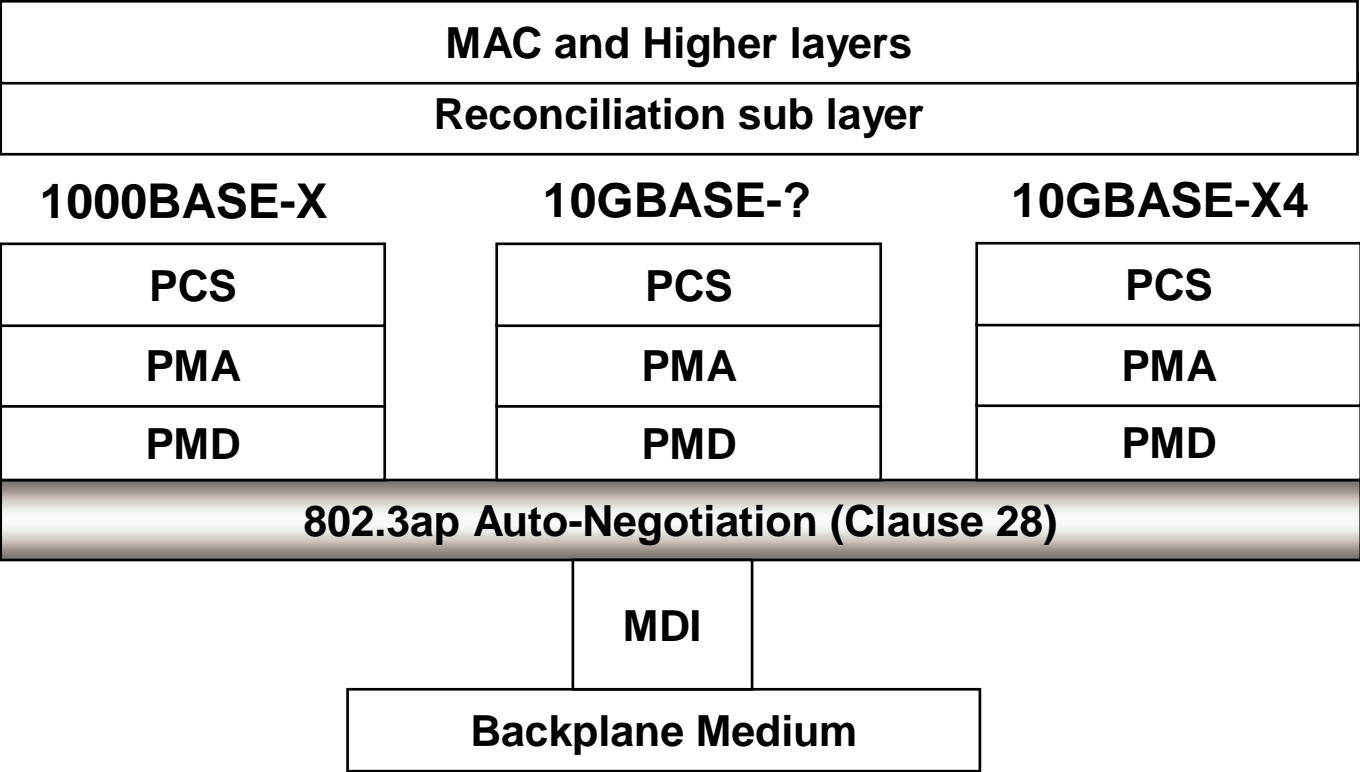Andre Szczepanek   Texas Inst

Objective

- Location of AutoNeg function to be below PMD as shown in layer model (Figure 28-2) [4]

- New base page and selector fields for 802.3ap Backplane Ethernet
  - Minimize number of pages exchanged

- Use Proposed SERDES compatible FLP [1]

- Use Clause 28 state machines for exchanging pages

High Level Layer Model

MAC and Higher layers
Reconciliation sub layer

1000BASE-X	**10GBASE-?**	**10GBASE-X4**
PCS	PCS	PCS
PMA	PMA	PMA
PMD	PMD	PMD

802.3ap Auto-Negotiation (Clause 28)

MDI

Backplane Medium

Layer Model

Clause 28 background

- Established for copper technologies and can Negotiate Multiple speeds
- Clause 28 state machines verified over years and have been made robust
- 7 years of AN Interoperability testing shows that most issues are associated with Software/Drivers that control the AN process (Device Management)
    - The protocol and state machine itself is robust
    - Most problems show up when system does not properly use the information provided by the AN protocol[2]
    - Initial interoperability tests focused on accuracy of AN State Machines but later new tests were added to focus on Device Management to address system level issues (Reference: [2] UNH-IOL Clause 28 AN management system test suite

Advantages of using Clause 28

- Auto-Negotiation function located below the PMD layer (Fig 28-2) [4]
  - Perfect position of sub layer within PHY
  - Ability to negotiate multiple speeds
- Ability to work with different signaling
  - NRZ and non NRZ signaling (MLS)
- Does not depend on PCS encoding
- Self Clocking
- Interoperability issues have been identified and most issues are associated with Device Management
- The state machine has been field proven over multiple PHY generations

Clause 28 Base Page
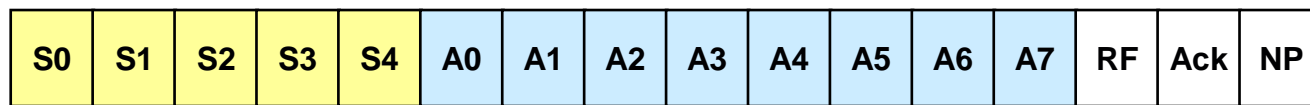
Clause 28 Base Page definition

S0	S1	S2	S3	S4	A0	A1	A2	A3	A4	A5	A6	A7	RF	Ack	NP

Next Page

Acknowledge

Remote Fault

Table 28A–1—Selector Field value mappings

S4	S3	S2	S1	S0	Selector description
0	0	0	0	0	Reserved for future Auto-Negotiation development
0	0	0	0	1	IEEE Std 802.3[®]
0	0	0	1	0	IEEE Std 802.9[®] ISLAN-16T
0	0	0	1	1	IEEE Std 802.5[®]
1	1	1	1	1	Reserved for future Auto-Negotiation development[a]

[a]For up-to-date information on the allocation of Auto-Negotiation Selector fi[...]
http://www.ieee802.org/3/selectors/selectors.html

Table 28B–1—Technology Ability Field bit assignments

Bit	Technology	Minimum cabling requirement
A0	10BASE-T	Two-pair category 3
A1	10BASE-T full duplex	Two-pair category 3
A2	100BASE-TX	Two-pair category 5
A3	100BASE-TX full duplex	Two-pair category 5
A4	100BASE-T4	Four-pair category 3
A5	PAUSE operation for full duplex links	Not applicable
A6	Asymmetric PAUSE operation for full duplex Links	Not applicable
A7	Reserved for future technology	

Proposed 802.3ap Base Page

Clause 28 Base Page definition

S0	S1	S2	S3	S4	A0	A1	A2	A3	A4	A5	A6	A7	RF	Ack	NP

→ Next Page

→ Acknowledge

→ Remote Fault
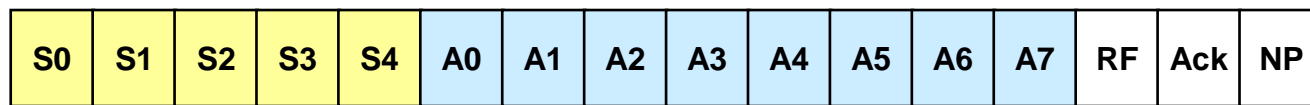
Proposed selector field for 802.3ap

S4	S3	S2	S1	S0	Selector description
0	0	0	0	0	Reserved for future Auto-Negotiation development
0	0	0	0	1	IEEE Std 802.3
0	0	0	1	0	IEEE Std 802.9 ISLAN-16T
0	0	0	1	1	IEEE Std 802.5
0	0	1	0	0	IEEE Std 1394
0	0	1	0	1	IEEE 802.3ap Backplane Ethernet
1	1	1	1	1	Reserved for future Auto-Negotiation development

Proposed 802.3 Base page bit assignments

Bit	Technology field bit assignments
A0	802.3ap 1Gb/s 1-Lane
A1	802.3ap 10Gb/s 1-Lane
A2	802.3ap 10Gb/s 4-Lane
A3	Reserved for Future Technology
A4	Reserved for Future Technology
A5	Pause Operation
A6	TBD
A7	TBD

Next Page Assignment

- Continue to have Next Page for future proofing and to negotiate additional parameters if any
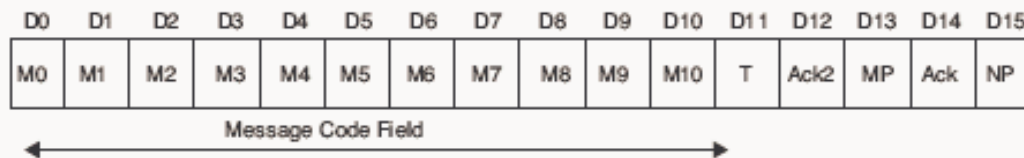- Next Page encodings same as Clause 28.2.3.4

D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
M0	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	T	Ack2	MP	Ack	NP

Message Code Field

Figure 28–11—Message Page encoding

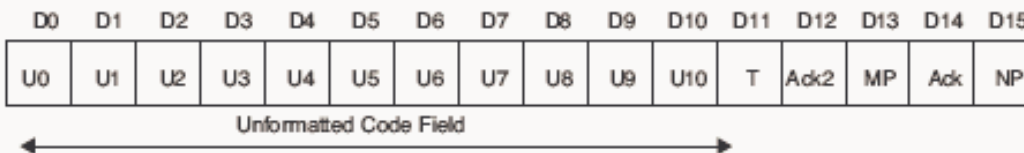| D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
U0	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	T	Ack2	MP	Ack	NP

Unformatted Code Field

Figure 28–12—Unformatted Page encoding

Functional reference diagram

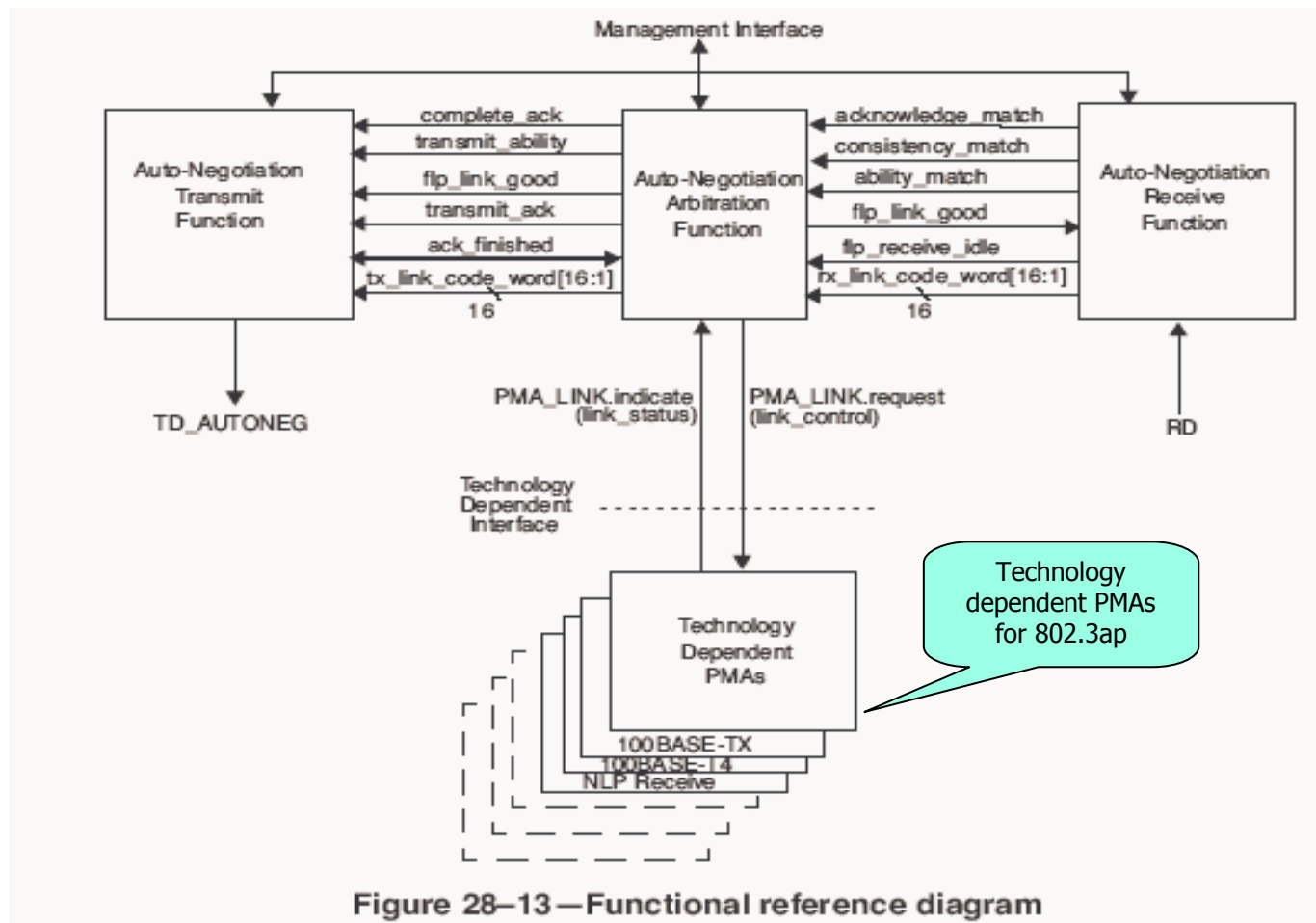- Use Clause 28 functional reference diagram

Figure 28–13—Functional reference diagram

Transmit & Receive state machines

- Use Clause 28.3 State diagrams and transmit/receive/arbitration state machine definitions for exchanging base and next pages [4]

- The state diagram timers to use clause 28.3.2 definitions
  - Some of the timer variables could be redefined for faster link convergence
  - Goal: maximum 3 sec for link convergence

- NLP Receive link integrity state diagram is not needed and all reference in state machines will be removed for 802.3ap

Management Data Interface

- Use Clause 45 MDIO interface and Register space [4]
    - Clause 22 Management frame format
    - Clause 45.4 Electrical interface definition
    - Clause 45.2.1 PMA/PMD register set definition
- Use Clause 45 interface (ST=00) to access Clause 45 registers
    - Access Clause 22 registers if present in a legacy device through Clause 45 management interface (Register 2.5.0 & STcode =01)
    - Other options considered: Using Clause 22 mechanism to access Clause 45 register set (Leverage mechanism defined by 802.3ah EFM [5])
    - Since there is no need to access control bits relevant to 10/100/1000 twisted pair operation it is proposed to use clause 45 interface to access clause 45 register space

Management Registers

- Use Clause 45.2.1 PMA/PMD register set [4][5]
    - Define additional bits and registers for 802.3ap
    - Lot of space available for future proofing
- Define 1.0.5:2 speed selector bits for 1G speeds: 0x00=10Gb/s; 0x01 taken by EFM; 0x02=1Gb/s
    - Add 1Gb/s speed ability bit to Register 1.4.3 to indicate 1G speed (Table 45-5)
- Bit 1.5.0 to indicate clause 22 registers implemented and accessed through clause 45 interface
- Bit 1.5.1 indicates PMA/PMD device present in package
    - Define 1.7.4:3 (two bits) to indicate different 802.3ap PMA/PMD types
    - Add additional bits to the 10G PMA/PMD extended abilities register (Register 1.11) to indicate 802.3ap PMD types (Bits:1.11:3:2); Bit 1.11.0 taken by 10GBASE-CX4 and 1.11.1 possibly by 10GBASE-T
- Continue to use Registers 1.9 and 1.10 for Transmit/Receive functions
- Define 1.110 to 1.1xx new registers for 802.3ap specific functions

Summary

- Locate Auto-Neg function to be below PMD as shown in layer model (Figure 28-2) [4]
  - New base page and selector fields for 802.3ap Backplane Ethernet
  - Use Proposed SERDES compatible FLP [1]
- Use Clause 28 state machines for exchanging pages [4]
- Provide an informative annex for operation with legacy devices not supporting 802.3ap Auto-Negotiation

References

- [1] SERDES compatible FLP AN proposal for 802.3ap, July 04 Plenary
    - http://ieee802.org/3/ap/public/jul04/szczepanek_02_0704.pdf
- [2] UNH-IOL Clause 28 Auto-Negotiation Management System Test Suite, UNH IOL Ethernet Interoperability Testing presentation
    - http://ftp.iol.unh.edu/fec/anegSystem.pdf
    - http://www.nbl.org.tw/nbl_old/nbl-iol-workshop/07_Ethernet_Overview.pdf
- [3] Earlier Auto-Neg presentations to Backplane Ethernet SG/TF
    - http://www.ieee802.org/3/bladesg/public/mar04/chang_01_0304.pdf
    - http://www.ieee802.org/3/ap/public/may04/ganga_01_0504.pdf
- [4] IEEE Std 802.3-2002, IEEE Std 802.3ae-2002
- [5] IEEE Std 802.3ak-2004, P802.3ah approved draft D3.3 (to be published as IEEE Std 802.3ah-2004)