Fast Synchronization Mechanism for 1000BASE-T1

IEEE 802.3bp - Plenary Meeting - March 2014

William Lo, Marvell

Objective

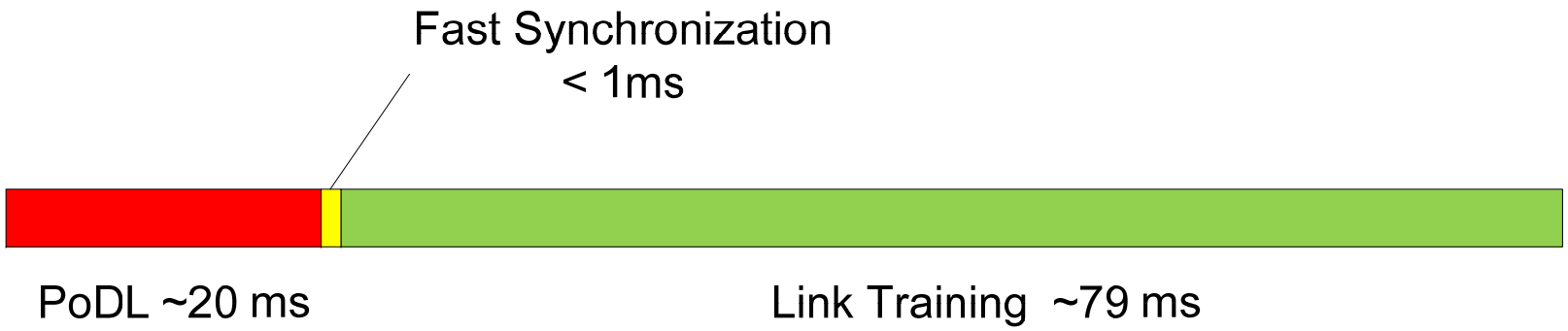
- Propose a mechanism that can quickly synchronize PHY and link partner prior to link training
- Synchronization allows common timeout start times to break any lockups that may occur during link training
- Discuss side benefits

Agenda

- Need for fast synchronization
- Basic Concept
- What can we leverage

The Big Picture

- **Proposed Fast Synchronization occurs after power up and before link training**
- **Overall power up to link up goal within 100ms**



Clause 28 Auto-Negotiation – The Bad and the Good

- **1000BASE-T1 is designed to operate without Clause 28 Auto-Negotiation used in 10/100/1000BASE-T**
  - **Closed system**
  - **Single pair**
- **Clause 28 Auto-Negotiation is slow**
  - **Designed to be backwards compatible to 10BASE-T – long pulse spacing**
  - **Loose link down time – (break_link_timer - 1.2 to 1.5 seconds)**
  - **Slow link up time – (link_fail_inhibit_timer – 0.75 to 1.0 seconds)**
  - **Legacy – (autoneg_wait_timer – 0.5 to 1.0 seconds)**
- **But Auto-Negotiation gives a standardized mechanism to restart link training in case PHYs cannot link up on initial attempt**
  - **Timeout after 0.75 to 1.0 seconds if link cannot be established by that time**
  - **Establishes a common timeout start time**
  - **Escape path from lock up due to any reason**
  - **Eliminates incompatible vendor dependent re-try implementation**

Need For Startup Synchronization

- 1000BASE-T and 10GBASE-T PHYs occasionally require multiple attempts at link training due to link not coming up on the first attempt
- Clause 28 Auto-Negotiation provides common timeout timer
- 1000BASE-T1 dual-duplex architecture similar to 1000BASE-T and 10GBASE-T
  - Hence will run into similar link training issues
- Need fast synchronization mechanism for 1000BASE-T1 to implement common timeout timer

Exchanged Signals

- Should be meaningful to differentiate from noise
- Easy to detect without need for DSP
- Exchange should terminate deterministically so timeout timers in both PHYs start at approximately the same time
- Tolerant to Noise
- Fast

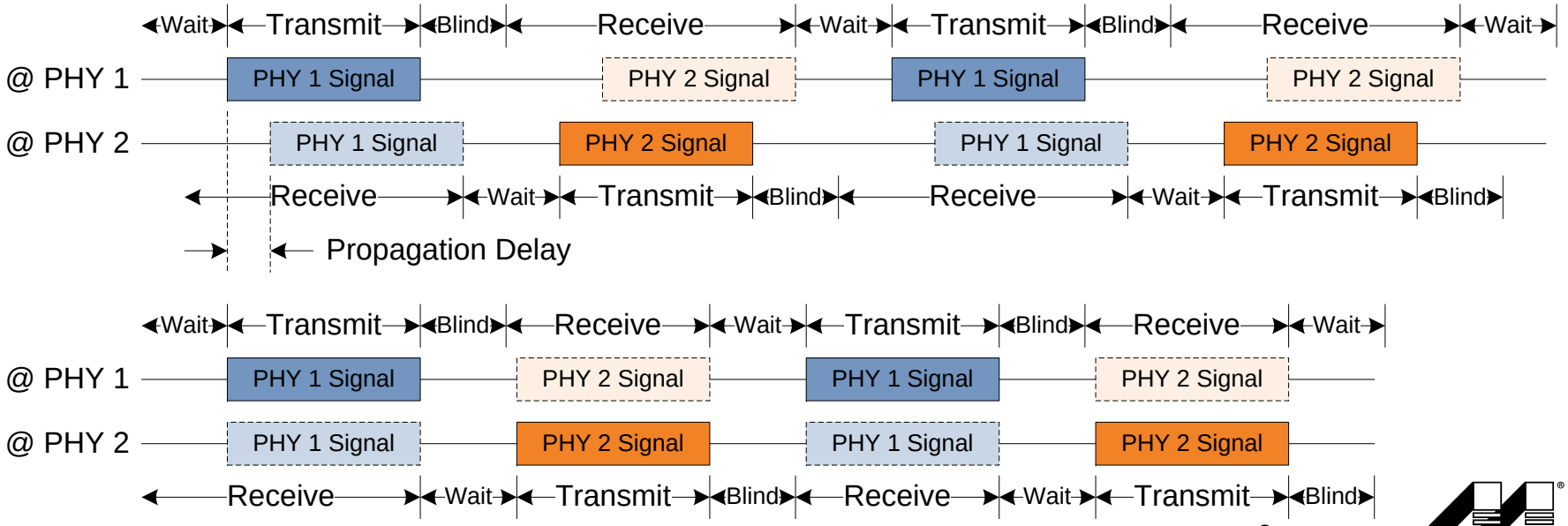
- So what mechanism has the above properties ….

Leverage Clause 73 Auto-Negotiation for Backplanes

- **Backplane Auto-Negotiation has all the desired properties**
  - Should be meaningful to differentiate from noise ➔ Coded bits
  - Easy to detect without need for DSP ➔ Oversample without equalization
  - Exchange should terminate deterministically so timeout timers in both PHYs start at approximately the same time ➔ State Machine
  - Tolerant to Noise ➔ Bits compared and checked in protocol
  - Fast ➔ 1000's times faster than Clause 28
- **Need to change timer values for single twisted pair**
  - Under 0.8 ms to sync up before DSP training
- **Need to change electrical signaling levels for twisted pair**
  - Transmit – use 1000BASE-T1 transmitter
  - Receive – Simple comparators
  - Actual electricals TBD – Will make compatible to 1000BASE-T1 levels
- **What's new – Making this work on one pair instead of 2 pairs**

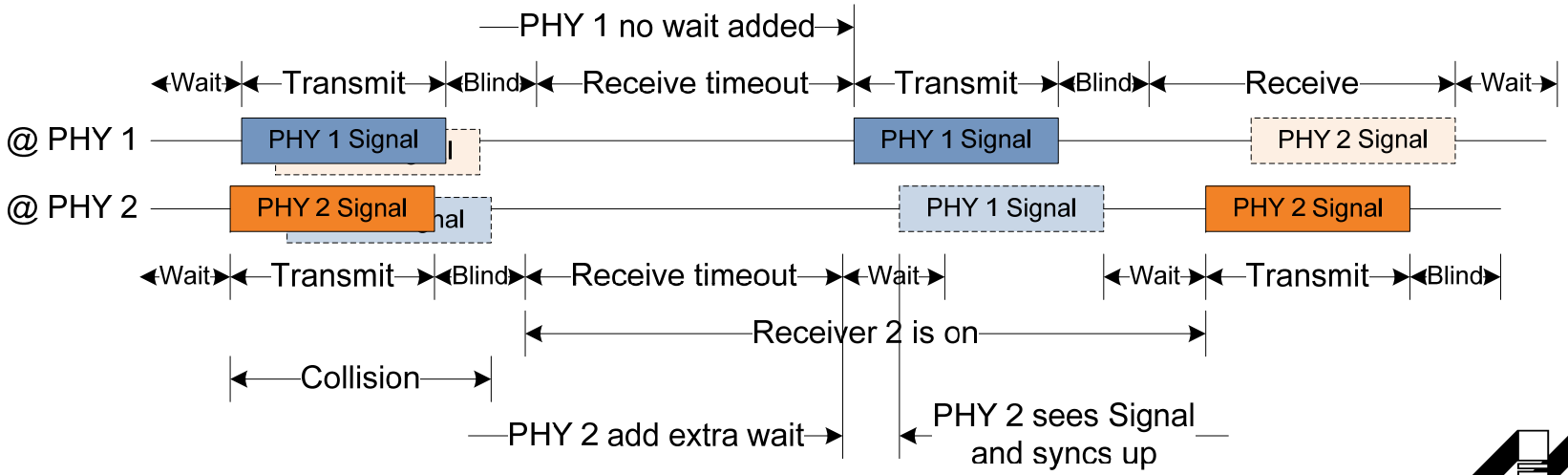
General Concept Over Single Pair

- PHYs take turns sending and receiving signals from each other
- Blind period to avoid seeing echo from self
- After signal received Wait (Silent) period needed since link partner may be in Blind period
- Wait period slightly longer than Blind Period
- Examples below with max cable length and zero cable length



Signal Separation on Startup

- **Both transmit overlap and no signal seen – receive times out**
- **PHYs will randomly decide whether to delay zero or more additional Wait periods while still keeping receiver on**
  - **Assuming 16 possible delay settings 1 in 1 trillion chance of going beyond 10 tries**
- **PHY that waits more should receive signal and should sync up system and no more random waits are needed**
- **At startup PHY should always listen for one Wait period before transmitting anything**

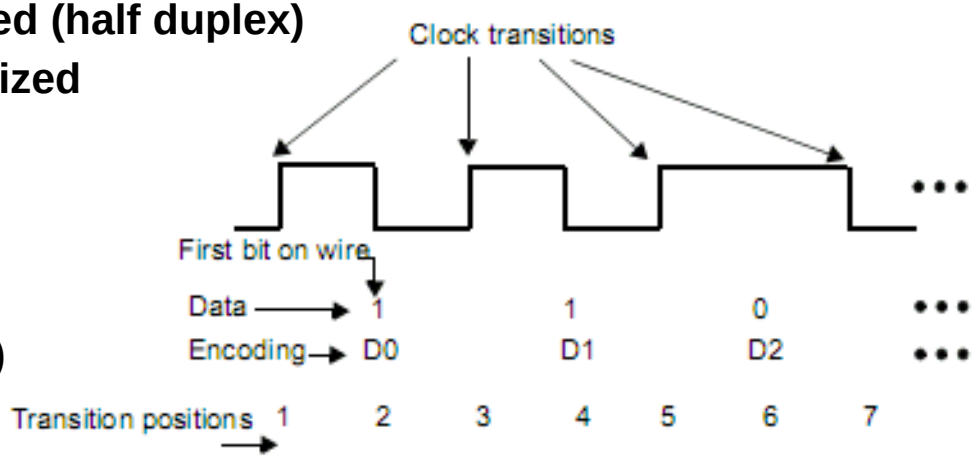


BTW - Information Can Be Exchanged While Syncing

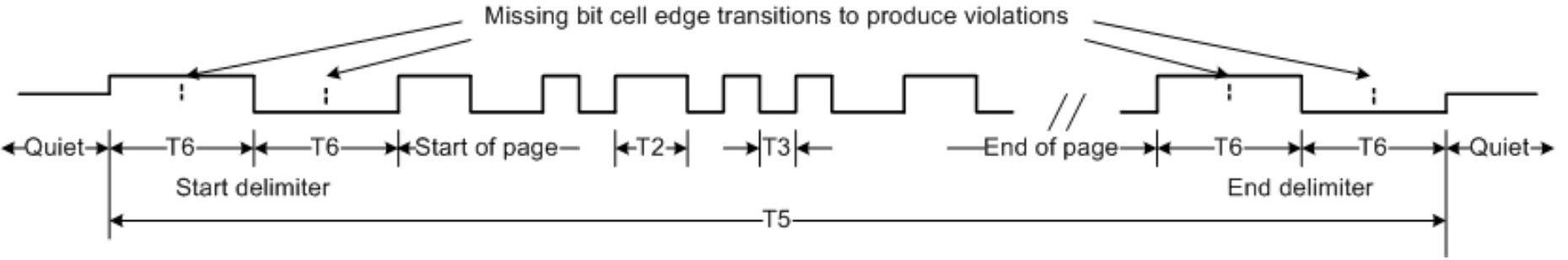
- **Simplifies Configuration**
  - No need to track all the configuration permutations (Switch to End node, vs Switch to Switch, EEE capabilities, this model car to that model device, etc.)
- **Easier Field Servicing / Upgrades**
  - Configuration smarts built into device
  - Field technician does not have to do manual configuration (minimizes mistakes)
  - Plug and Play
- **Future Proof**
  - Current devices don't need to know future capabilities
  - Flexibility in future PHYs with higher speed capabilities
- **Proven Concept in Ethernet**

Half Duplex Differential Manchester Encoded Signaling

- **Clause 73 Differential Manchester Encoding**
  - **But not continuously transmitted (half duplex)**
  - **DC balanced, Partially Randomized**
  - **Bits bounded by delimiters**



- **40 ns transitions**
  - **(Clause 73 is 3.2 ns transitions)**
  - **80 ns per bit**
  - **4560 ns per page**
    - **(1000's times faster than clause 28)**



What Changes Are Needed

- Start with 802.3ap Clause 73 Auto-Negotiation
- Adapt DME mechanism to copper media
- Small modifications to existing Arbitration, Transmit, and Receive State machines and timer changes.
- Add new state machine to control half duplex over single pair
- Additional tweaks possible to speed up
  - Eliminate Master/Slave collision
  - Reduce number of redundant pages sent
- 1000BASE-T1 PCS and PMA specification must define fast link down detection
- State Machine details to be released in future presentation.

Proposal

- **Require a synchronization mechanism to be run prior to link training to implement common timeout timer for 1000BASE-T1**
- **Start an ad hoc group to study modifying Clause 73 Auto-Negotiation for use as synchronization mechanism**

- **Benefits**
  - **Synchronize PHYs for predictable timeout to break lockup conditions**
  - **Allows exchange of information prior to link training**
  - **Simplifies configuration, field upgrades**
  - **Future proofing**
  - **Based on proven Ethernet concepts**

THANK YOU

BACKUP

Startup Times With Proposed Values

- break_link_timer – proposed 100 us
- Startup retry resolution per attempt - worst case wait
  - DME page + Blind period + receive time out + Wait period =
    4.56 us + 2.0 us + 6.8 us + 15 * 2.16 us = 45.76 us
- Once in sync each pair of pages takes
  - 2 x (Wait period + DME page + propagation) =
    2 x (2.16 us + 4.56 us + 1.0 us) = 15.44 us
- Base page exchange
  - 3 in Ability Detect, 3 in Acknowledge Detect, 6 in Complete Acknowledge
    = (3 + 3 + 6) * 15.44us = 185.28 us
- DSP linkup time
  - RTPGE Group to define based on modulation scheme and PCS
- Total time not counting DSP link up time
  - No retry – 100 us + 185.28 us < 300 us
  - 10 retry – 100 us + 10 x 45.76 us + 185.28 us < 750 us