Duration of Half-Duplex Training

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Supporters

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Overview

- There is a proposal to reduce the duration of the half-duplex phase of training
  - majomard_060722
  - majomard_061922

- This is to present counter-arguments and suggest that we should be cautious in reducing this training time

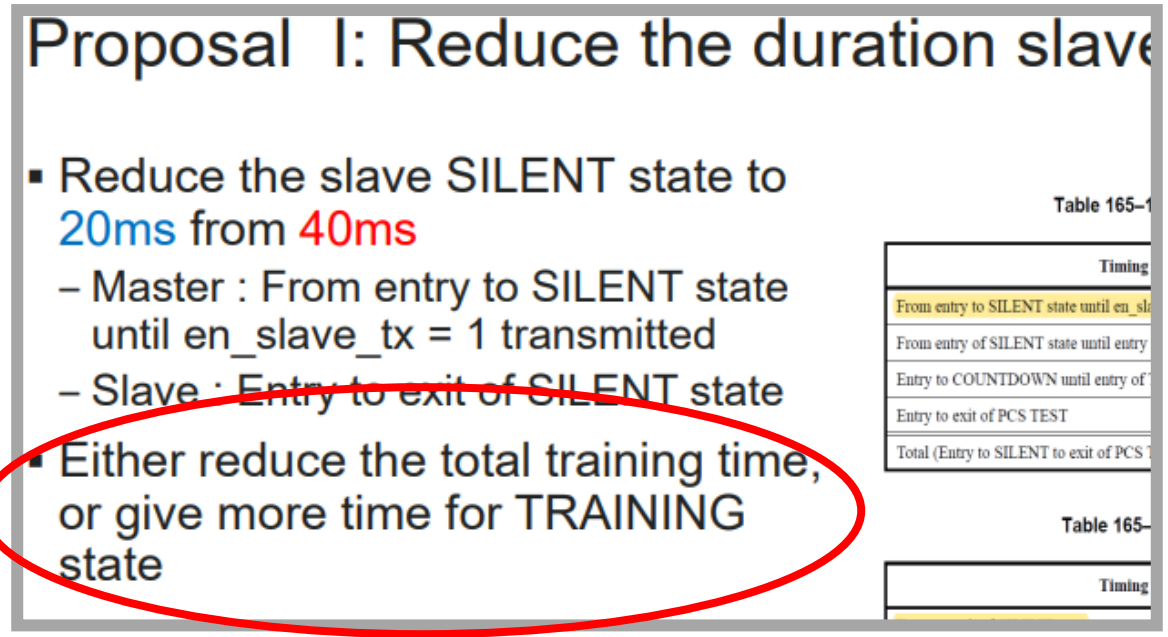
Background: Training Time

- The overall training time is no more than ~100 ms
- There are 2 major training phases: half-duplex and full-duplex
- Half-duplex:
  - Master transmits while Slave is quiet
  - Master trains its echo canceller while Slave recovers timing and train equalizers
  - Duration is no more than ~40 ms
- Full-duplex:
  - Both Master and Slave transmit simultaneously
  - All filters are trained and optimized for link

Benefits of Reducing Half-Duplex Time (Quoted from majomard_060722)

The following are mentioned as the motivations the proposal:

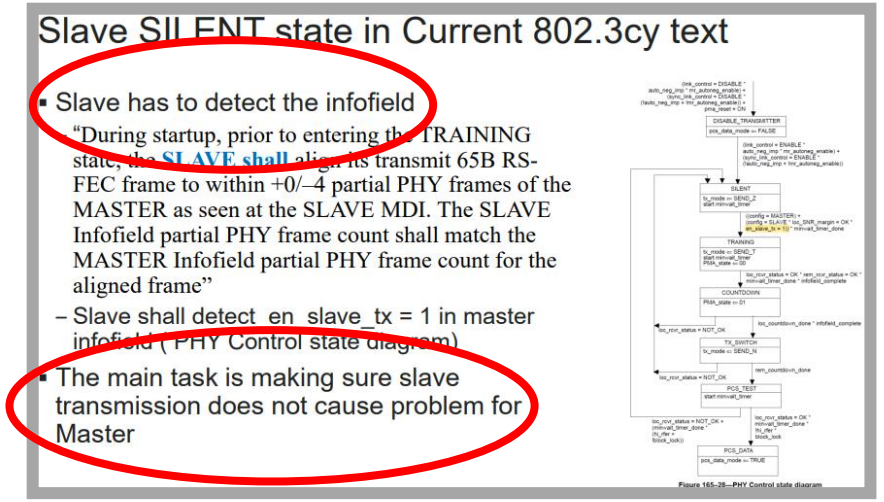
- To reduce the overall training time
  - Removed in a later presentation
- To allocate more time to full-duplex training

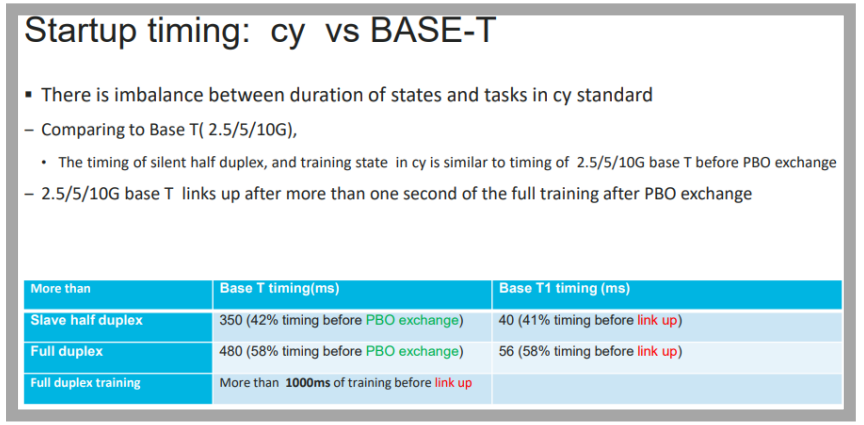


slide 4 of majomard_060722

Feasibility Arguments (Quoted from majomard_061922)

- Slave can quickly open the eye to detect Infofield
- Master can do decent echo cancellation quickly
- Since half-duplex period of 10GBASE-T is ~20% of overall training time, it should also have the same proportion in 25GBASE-T1





More than	Base T timing(ms)	Base T1 timing (ms)
Slave half duplex	350 (42% timing before PBO exchange)	40 (41% timing before link up)
Full duplex	480 (58% timing before PBO exchange)	56 (58% timing before link up)
Full duplex training	More than **1000ms** of training before link up	

slides 6 and 7 of majomard_061922

Training Functions During Half-Duplex

- Slave training functions include some or all of the following:
  - Initial estimation of the channel
  - Analog configuration
  - Equalizer initialization
  - Timing recovery
  - Equalization training
- At the end of half-duplex training, the Slave is expected to
  - Have opened the eye to detect Infofield
  - Achieve timing lock
- Master operation is primarily limited to echo canceller training

Complexity of Slave Training in Half-Duplex

- During half-duplex training, Slave has to
  1. Equalize the channel
  2. Capture the frequency offset
  3. Lock to the optimal phase
  4. Identify the training signal

- These operations have to be done
  - All simultaneously
  - From starting points which may be far off from optimal

- These challenges may not be present in full-duplex training and data mode as some of these tasks are already completed or the operating point is already close to the optimal

Complexity of Slave Training – cont'd

The operating regime of the receiver is very different from full-duplex and data mode

- With receiver starting far away from nominal operating point
- With nonlinear and complex behavior of interdependent and interacting timing loop and equalizer adaptation loop
- With the possibility of being stuck in trivial solutions or local minima

➔ Hard to analyze for a tight upper bound on training time

Complexity of Slave Training – cont'd

While the SNR requirement to open the eye is low, there are corner conditions with the possibility of

- Much longer training time to open the eye
- Complete failure to open the eye
- Opened eye but with slowly-drifting phase

Importance of Slave Training in Half-Duplex

- If Slave is not able to open the eye and lock the phase, training fails which requires another fresh training attempt
  - ➔ violates the requirement to bring up the link in less than 100 ms
- It is expected that the rate of training failure to be very low

- The allocated budget to half-duplex training is a limit on the maximum dwell time
  - If the eye is opened quickly the transition to full-duplex may happen earlier
  - The maximum dwell time should accommodate the longer training time for corner cases

Baud-Rate and Training Time

- With higher baud-rate, there are more training symbols available in unit time
  - Full-duplex training can take advantage of this fact for shorter training time
- The initial training time in half-duplex may be more limited by the dynamic response of the PLL and not as much by the number of available symbols
- The dynamic response of the PLL and timing control loop does not necessarily scale with baud-rate
  - The higher signaling bandwidth and the tighter clock jitter requirement may contribute to a slower response

Comparison to 10GBASE-T

The half-duplex portion of 10GBASE-T training is only ~20% of the total training time. Can this be extended to 25GBASE-T1?

- 10GBASE-T training is much more complex than 25GBASE-T1
- There are significant interruptions in system in the middle of training:
  - Transmit power changes
  - THP is engaged
- There is no counterpart to these events in 25GBASE-T1 training

➔ Comparison to 10GBASE-T may not be fair

Summary

- Slave training in half-duplex is not trivial
- While the half-duplex training goals may not be typically hard to achieve, there are corner cases that may demand long training time
- A failure in half-duplex training results in violation of the maximum 100 ms of startup time
- The duration of half-duplex training may not shrink linearly by the higher baud-rate
- The allocated time is a *maximum*, not preventing an earlier transition to full-duplex while accommodating the corner cases

➔ A reduction in duration of half-duplex has to be studied carefully