# 802.3bn Link Ad Hoc

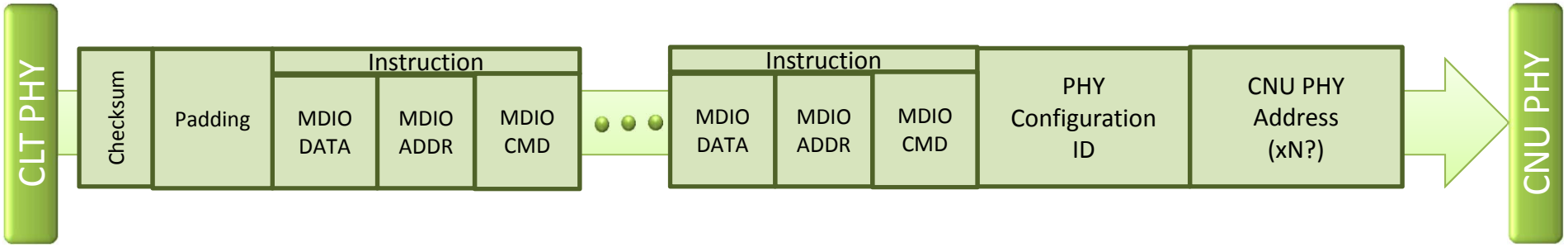
Status Update

Ed Boyd, Broadcom

# Review of Ad Hoc Calls

- Presentation on Downstream Synchronization – Duane Remein, Huawei
- Presentation on PLC Forward Error Correction – Avi, Broadcom
- Presentation on Downstream Pilots - Nicola Varanese, Qualcomm
- Started Discussion on Downstream PHY Link Framing

# PHY Link Data Packet (Downstream)




| | |
|---|---|
| Frame Size | Should we have a fixed size or variable size?<br>Variable size would require a length.<br>Do we want to align this with OFDM frame? |
| Ack or No Ack | Do we have a bit (command) to trigger an upstream response? |
| Checksum or FEC? | Do we need FEC or is modulation order low enough to get high enough error? Additional logic. |
| Chained Addressing? | Can we address consecutive registers with the address field? |
| MDIO addressing | Can we use the MDIO address MAP to match the PLC addressing? |
| PHY Address | Do we want to have multiple CNU PHY's (other than broadcast) off a single message? |
| PHY Address | What is it? MAC Address? |

PHY Link Ad Hoc

# STRAW POLLS

# Straw Poll #5

- The downstream PHY link channel should be a dedicated set of carriers in every downstream symbol (isolated from MAC data).

- Y: 13
- N: 0
- Abstain: 8

# Straw Poll #6

PHY-Link register

I think that the read/write capability of all/nearly all CNU PHY registers should be the same between the PHY-Link (from CLT) and MDIO (from CNU)

| | |
|---|---|
| Yes | __4___ |
| No, some | _____ |
| No, None | __1___ |
| Abstain | __ 3 ___ |

# Straw Poll #7

I think that the downstream PHY Link should include an error correcting code?

Yes ____

No _____

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# THANK YOU!

PHY Link Ad Hoc

# PHY LINK MOTIONS

# Motion #3

- The Downstream PHY Link Channel shall use a fixed modulation order of 16 QAM to carry PHY link information.

- Mover: Ed Boyd
- Seconder: Kevin Noll

- Y: 39
- N: 0
- Abstain: 0

- Technical Motion >=75%

# Motion #4

- A CNU shall auto-detect the CP size and sub-carrier spacing of the downstream PHY Link Channel

- Y: 40
- N: 0
- Abstain: 0

- Mover: Ed Boyd
- Seconder: Juan Montojo

- Technical Motion >=75%

# Motion #5

- The Downstream PHY Link Channel shall use the same CP size and symbol duration as the data channel.

- Y: 42
- N: 0
- Abstain: 0

- Mover: Ed Boyd
- Seconder: Eugene Dai

- Technical Motion >=75%

PHY Link Ad Hoc

# RUNNING DOCUMENTS

# Overview

- Objective
  - Define the process for the CLT PHY to connect to CNU PHY before the MAC is enabled.
  - Define any re-negotiation or PHY parameter procedure.
  - Define the PHY parameters to be configured over MDIO & Auto-Negotiation
  - What happens after CLT PHY & CNU PHY power up?
  - What parameters are PHY? (others are MAC)

- Output of the Ad Hoc
  - Baseline proposal
    - A single agreed solution is best.
    - Two or more options with pros and cons is the other option.
  - Joint Presentation for next meeting

# Link Topics

- Link Transport Methods
  - Upstream
  - Downstream
  - e.g. Time Inserted or Frequency Inserted, or other
  - Protocol
- Auto-negotiation-Link state machine
  - Finding the Downstream
  - Speeding up the process
  - Initial Upstream
- Message Format & Addressing
  - e.g. Address + Register Pages
- Protocol
  - Dynamic or Static: Master or Slave, who makes change
  - e.g. Echo Protocol
- Parameters and Status Indicators
- MAC Discovery Compatibility

# Parameters & Status Indicators

**System Wide Possible**

- TDD or FDD
- Power management control
- Note: Probing of the entire data channel would be handled in the MAC channel and not PHY link channel

**Downstream Definition Possible List**

- Number of Downstream OFDM channels
- 192MHz OFDM Channels Characteristics
  - Center Frequency, ~~Cyclic Prefix~~, FEC, Interleaver type/depth, ~~symbol length~~
- 192MHz OFDM Channels: Available Sub-Carrier (Frequency allocation)
- 192MHz OFDM Channels: Sub-Carrier Modulation Order

**Upstream Definition Possible List**

- Upstream PHY Link Channel frequency
- Number of Upstream OFDM channels
- 192MHz OFDM Channels Characteristics
  - Center Frequency, Cyclic Prefix, FEC, Interleaver type/depth, symbol length
- 192MHz OFDM Channels: Available Sub-Carrier (Frequency allocation)
- 192MHz OFDM Channels: Sub-Carrier Modulation Order
- Transmit Power Level
- Transmit Offset

**Does not carry MAC Layer or above Frames (Configuration for upper layers could be carried)**

# Start Up Time Budget

- Finding the Downstream Channel
  - Hunt frequency and find preamble(Estimate at 2 seconds)

- Configuration for Downstream MAC channel
  - 1 second to transfer sub-carrier configuration

# Evaluation Criteria

- Link establishment time.
- Simplicity
- Must work all of the time
- Must work below the MAC
- Bandwidth used

# Definitions

- PLC – PHY Link Channel

# LINK TRANSPORT

# Link Transport Notes

- How many CNUs are supported?
  - In general, this is a design specification issue but we need to size fields.
  - Fields should be 15 bits to match LLID size.
  - Practical Numbers for analysis: 256 CNU PHYs per CLT PHY. (8 LLIDs per CNU, what does really mean to the PHY?)
- Do we need a Link configuration on the CLT PHY for every CNU PHY?
  - Some parameters will be common but others will be unique.
  - If we have to specify transmit power, delay offset, etc; they would be unique.
- How wide is the frequency transport?
  - Broadcom Proposal: 32x50KHz = 1600KHz
  - …
- How fast does it need to be? What is the data rate?
- How is the initial contention handled?
  - Broadcom Proposal: Random Symbol Offset or backoff a number of slot opportunities
- Do we need to detect collisions or just provide avoidance?
  - Broadcom Proposal: Avoidance
- How do we find the initial downstream channel?
  - Broadcom Proposal: Stored from previous position. Hunt based on 6MHz and/or 8MHz center frequencies.
- Do we need to acknowledge information from CLT PHY to CNU PHY?
- How fast do things change in the Network?
  - Updates in minutes.

# Link Transport Notes

- How do we handle ingress noise on PHY link channel?
  - Double the channel
  - Move the channel
  - Avoid placing it on top of ingress, use clean spectrum, low modulation order. Only move if required.
- Do we define a grid position for the PHY link channel to simplify searching?
  - One location in a 24MHz channel? (Centered or first carriers or last carriers?)
  - One location in 6MHz and/or 8MHz channel grid? (Centered or first carriers or last carriers?)
  - One location in 2MHz channel grid? (Centered or first carriers or last carriers?)
- We need to define a fixed pattern (preamble) in the downstream PHY link channel
  - Can we use a CP instead of a preamble?
  - Fixed period?
- How do we transport multiple profile configurations if needed?
  - Option 1: Carry base profile in PHY link channel and bring up MAC with it. Use OAM to configure additional profiles.
  - Option 2: Configure all profiles in the PHY link channel.

# Link Transport – Downstream Channel

- Two Options
  - Dedicated Subset of Carriers, Continuous
  - Subset of Carriers, periodic block of PHY link data
    - Spread out
    - Clumped
  - Symbol on all carriers
- How many PHY link channels do you need in the downstream?
  - 1 per 192 MHz
  - 1 for entire downstream
- How much data is needed in the channel?
- What is the modulation order for the PHY Link Data?
  - 16QAM is the most likely choice
- How much preamble is needed in the channel?
  - 1 symbol might work with auto-correlation
  - 2 symbols is simpler
- How many sub-carriers to make detection stable?
  - Channel model needed to be sure.
  - We can make a choice now but we will need to revisit
- We need to define a fixed pattern (preamble) in the downstream PHY link channel
  - Can we use a CP instead of a preamble?
  - Fixed period?

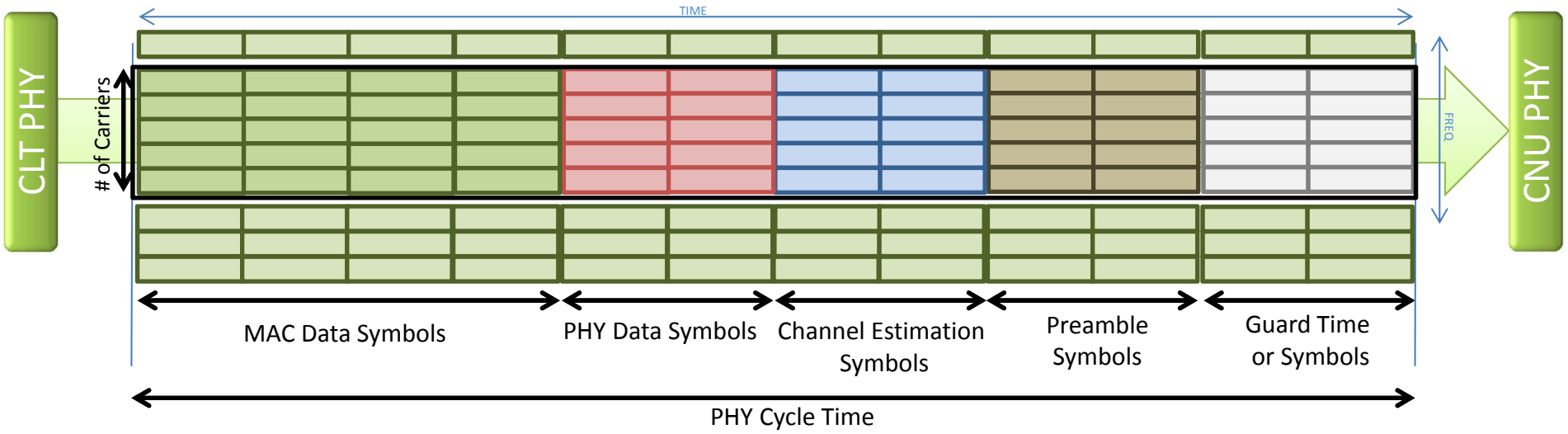
# Link Transport – Downstream Data Rate

- Determine the required rate
  - Guessing the bandwidth of configuration of the modulation [channel worst case]
    - 4 channels (of 192MHz) x 16K carriers per block x byte per carrier = 64K Bytes
    - If initial configuration time of 1 second is required, then 64K Bytes needs 512Kbps
    - Double this so 1Mbps.
    - 1Mbps @ 16QAM is 256KHz
      - without overhead, 5 carriers at 4K FFT, 50KHz
      - 1% at 24MHz
    - Duane to expand on the analysis

# Link Transport – # of Channels

- Do we want 1 PHY link of 1Mbps per 192 MHz channel downstream?
  - Is it a unique channel or just a duplicate if isolated channels?
  - Option 1: downstream is unique per 192MHz but upstream information would be the same if sharing the same upstream channel. All center Freq of downstream 192MHz blocks
  - Option 2: Duplicate entire PHY link so a multiple channel only needs to listen to 1 for all information
  - Option 3: Single PHY Link channel. Any lower capabilities CNU must listen to common channel that carries the PHY Link channel.
  - The decision for 1 per 192MHz or 1 per downstream can be linked to the decision on required CNU channel support. The PLC must follow this decision.
- Do we want 1 PHY link of ?Mbps per ? MHz channel upstream?
  - For TDD, upstream and downstream channel count would likely be the same.
  - Multiple PHY Link channels will use 2 transmitters out of the limit
  - Number of transmitters limit will grow as channel size increases?

# Downstream PHY Link Channel




| | Bounds | Option 1 - FDD | Option 2 - FDD | Option 1 - TDD | Option 2 - TDD |
|---|---|---|---|---|---|
| PHY Link Channel Width (# of Carriers x carrier width) | 1 to | 300KHz | 400KHz (easier to find) | | |
| Guard Time/Symbols | 0 to | 0 | 0 to X | RTT+SwitchTime + up-cycle | ? |
| Preamble Symbols | 1 to | 2 | 4 | | |
| Channel Estimation Symbols | 0 to | ? | ? | | |
| PHY Data Symbols | 1 to | ? | 1 to Z | | |
| MAC Data Symbols | 0 to | 0 | >0 | | |
| PHY Data Rate | >0 | | | | |

# Downstream PHY Link Channel

- Number of preambles of symbols?
  - Fixed pattern, BPSK, PN sequence is an example
  - 2 symbols is used in LTE
  - 2 maybe difficult to detect in bad SNR, 8 would be able to support bad SNR
  - Avi simulation results show 8 symbols has high detection rate
  - Avi will show presentation on results at the next meeting

- How often should preamble be repeated?
  - Every 128 symbols, 8 preamble symbols (1/16$^{th}$ of PHY link channel) [Avi]
  - Every

- Channel Width
  - 400KHz gives more room for overhead

- Sharing the PHY link carrier with the MAC layer Data
  - Wider Channel can be used if MAC data is included.
  - Wider Channel is better against fading
  - PHY link alone doesn't restrict the MAC data channel
  - Slightly variable on the MAC data channel with the gap
  - Simpler to have an isolated channel

# Downstream PHY Link Channel

- Do we need to detect symbol size (sub-carrier spacing) and CP size of PHY Link Channel?
  - Fixed is simpler but is it too restrictive and should be same.
  - It is not desirable for the data and the PLC to have different symbol size. Same FFT.
  - The PHY link CP and symbol size should be detected.
  - If we have 2 symbol sizes supported in the data channel, the PHY link channel will have 2 possible sizes.
    - The size of the PLC is constant (e.g. 400KHz)
    - 400KHz would be 8x50KHz carriers
    - 400KHz would be 16x25KHz carriers
- Cycle Size of PLC
  - Could be a configured size.
  - The maximum period will be defined so the searching time is known
  - The minimum period will be related to the frame alignment indication
- PLC preamble start relative to data channel frame alignment indication
  - The PLC position could be used to identify a known position in the downstream cycle for TDD.
  - In FDD, the PLC position could be aligned with pilot rotation

# Downstream PHY Link Channel

- Juan (Qualcomm) option
  - Can we narrow PHY Link Channel by using the pilot tones in the other symbols?
  - Pilots would replace preamble symbols in PLC.
  - Potentially easier to find the downstream channel.
  - Presentation for next week.

# Upstream PHY Link Channel

- PHY Link upstream
  - Narrow Channel
  - Sets the symbol boundary: Timing advance
- How do we send on all upstream carriers so we can “tune” the upstream?
  - Tuning is modulation selection, phase, amplitude, power
  - Tuning is a burst of pilots
  - Fixed cycle in the PHY – option 1
  - MAC triggered event – option 2
    - What should the MAC send and should it be put on the wire?
    - Would it make sense to send the FEC block?