802.3bn Link Ad Hoc

Meeting Notes & Baseline

Agenda, Notes – 3/6/13

- Conference Call at 11am-12
- IEEE Patent Policy Reviewed
- Attendance Taken – See slide
- Presentation on Downstream Synchronization (part 2) – Duane Remein
- PLC Forward Error Correction – Avi
- Updated Simulation Results - Nicola

Agenda, Notes – 2/28/13

- Conference Call at 9am-10am
- New Time will be Wednesday 11am for following meetings.
  - Based on doodle poll results.
- IEEE Patent Policy Reviewed
- Attendance Taken – See slide
- Presentation on Downstream Synchronization (part 1) – Duane Remein
- Started discussion on PHY Link Data Frame. See slide with generic model.

Agenda, Notes – 2/21/13

- Conference Call at 9am-10am
- IEEE Patent Policy Reviewed
- Attendance Taken – See slide
- Presentation from Nicola Varanese, Qualcomm on Continuous Pilots

Agenda, Notes – 2/14/13

- Conference Call at 9am-10am
- IEEE Patent Policy Reviewed
- Attendance Taken – See slide
- Downstream Transport discussion
  - If we have an isolated channel, can we make it narrower by knowing the pilots?
  - Juan, Qualcomm will present at a later meeting.
- Upstream Transport discussion
  - How do we measure the full channel at initial startup?
  - Can we use a MAC initiated time slot?
  - Ed, Broadcom will present at a later meeting.

PATENTS

Instructions for the WG Chair

The IEEE-SA strongly recommends that at each WG meeting the chair or a designee:

- **Show slides #1 through #4 of this presentation**
- **Advise the WG attendees that:**
  - The IEEE's patent policy is described in Clause 6 of the *IEEE-SA Standards Board Bylaws*;
  - Early identification of patent claims which may be essential for the use of standards under development is strongly encouraged;
  - There may be Essential Patent Claims of which the IEEE is not aware. Additionally, neither the IEEE, the WG, nor the WG chair can ensure the accuracy or completeness of any assurance or whether any such assurance is, in fact, of a Patent Claim that is essential for the use of the standard under development.
- **Instruct the WG Secretary to record in the minutes of the relevant WG meeting:**
  - That the foregoing information was provided and that slides 1 through 4 (and this slide 0, if applicable) were shown;
  - That the chair or designee provided an opportunity for participants to identify patent claim(s)/patent application claim(s) and/or the holder of patent claim(s)/patent application claim(s) of which the participant is personally aware and that may be essential for the use of that standard
  - Any responses that were given, specifically the patent claim(s)/patent application claim(s) and/or the holder of the patent claim(s)/patent application claim(s) that were identified (if any) and by whom.
- The WG Chair shall ensure that a request is made to any identified holders of potential essential patent claim(s) to complete and submit a Letter of Assurance.
- It is recommended that the WG chair review the guidance in *IEEE-SA Standards Board Operations Manual* 6.3.5 and in FAQs 12 and 12a on inclusion of potential Essential Patent Claims by incorporation or by reference.

Note: **WG** includes Working Groups, Task Groups, and other standards-developing committees with a PAR approved by the IEEE-SA Standards Board.

(Optional to be shown)

Participants, Patents, and Duty to Inform

All participants in this meeting have certain obligations under the IEEE-SA Patent Policy.

- Participants [Note: Quoted text excerpted from IEEE-SA Standards Board Bylaws subclause 6.2]:
  - "Shall inform the IEEE (or cause the IEEE to be informed)" of the identity of each "holder of any potential Essential Patent Claims of which they are personally aware" if the claims are owned or controlled by the participant or the entity the participant is from, employed by, or otherwise represents
    - "Personal awareness" means that the participant "is personally aware that the holder may have a potential Essential Patent Claim," even if the participant is not personally aware of the specific patents or patent claims
  - "Should inform the IEEE (or cause the IEEE to be informed)" of the identity of "any other holders of such potential Essential Patent Claims" (that is, third parties that are not affiliated with the participant, with the participant's employer, or with anyone else that the participant is from or otherwise represents)
- The above does not apply if the patent claim is already the subject of an Accepted Letter of Assurance that applies to the proposed standard(s) under consideration by this group
- Early identification of holders of potential Essential Patent Claims is strongly encouraged
- No duty to perform a patent search

Patent Related Links

All participants should be familiar with their obligations under the IEEE-SA Policies & Procedures for standards development.

Patent Policy is stated in these sources:

IEEE-SA Standards Boards Bylaws

http://standards.ieee.org/develop/policies/bylaws/sect6-7.html#6

IEEE-SA Standards Board Operations Manual

http://standards.ieee.org/develop/policies/opman/sect6.html#6.3

Material about the patent policy is available at

http://standards.ieee.org/about/sasb/patcom/materials.html

If you have questions, contact the IEEE-SA Standards Board Patent Committee Administrator at patcom@ieee.org or visit http://standards.ieee.org/about/sasb/patcom/index.html

This slide set is available at https://development.standards.ieee.org/myproject/Public/mytools/mob/slideset.ppt

Call for Potentially Essential Patents

- If anyone in this meeting is personally aware of the holder of any patent claims that are potentially essential to implementation of the proposed standard(s) under consideration by this group and that are not already the subject of an Accepted Letter of Assurance:
  - Either speak up now or
  - Provide the chair of this group with the identity of the holder(s) of any and all such claims as soon as possible or
  - Cause an LOA to be submitted

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- **All IEEE-SA standards meetings shall be conducted in compliance with all applicable laws, including antitrust and competition laws.**
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  - **Don't discuss specific license rates, terms, or conditions.**
    - Relative costs, including licensing costs of essential patent claims, of different technical approaches may be discussed in standards development meetings.
      - Technical considerations remain primary focus
  - **Don't discuss or engage in the fixing of product prices, allocation of customers, or division of sales markets.**
  - **Don't discuss the status or substance of ongoing or threatened litigation.**
  - **Don't be silent if inappropriate topics are discussed … do formally object.**

See *IEEE-SA Standards Board Operations Manual*, clause 5.3.10 and "Promoting Competition and Innovation: What You Need to Know about the IEEE Standards Association's Antitrust and Competition Policy" for more details.

ATTENDEES

Attendance – 3/6/13 Conf Call

- **Ed Boyd, Broadcom**
- **Marek Hajduczenia, ZTE**
- **Alan Brown, Aurora**
- **Curtis Knittle, CableLabs**
- **Joe Solomon, Comcast**
- **Duane Remein, Huawei**
- **Bill Powell, ALU**
- **Christian Pietsch, Qualcomm**
- **Nicola Varanese, Qualcomm**
- **Avi Klinger, Broadcom**
- **Hesham ElBakoury, Huawei**
- **Steve Shellhammer, Qualcomm**
- **Syed Rahman, Huawei**
- **Jim Farmer, Aurora**
- **Tom Staniec, Cohere**
- **George Hart, Rogers**

Attendance – 2/28/13 Conf Call

- **Ed Boyd, Broadcom**
- **Bill Keasler, Ikanos**
- **Marek Hajduczenia, ZTE**
- **Alan Brown, Aurora**
- **Curtis Knittle, CableLabs**
- **Joe Solomon, Comcast**
- **Raanan Ivry, Widepass**
- **Duane Remein, Huawei**
- **Bill Powell, ALU**
- **Christian Pietsch, Qualcomm**
- **Nicola Varanese, Qualcomm**
- **Leo Montreuil, Broadcom**
- **Steve Shellhammer, Qualcomm**
- **Syed Rahman, Huawei**

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- **Avi Klinger, Broadcom**
- **Hesham ElBakoury, Huawei**
- **Steve Shellhammer, Qualcomm**
- **Mark Laubach, Broadcom**
- **Syed Rahman, Huawei**
- **Leo Montreuil, Broadcom**
- **Juan Montojo, Qualcomm**

OVERVIEW & TOPICS

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?

Straw Poll #1

- Should the downstream PHY link channel be a fixed modulation order (e.g. QPSK, 16QAM, 64QAM)?

- Y: 27
- N: 1
- Abstain: 7

Straw Poll #2

- The PHY Link Channel should use 16QAM Modulation order?

- Y: 11
- N: 0
- Abstain: 0

Straw Poll #3

- The PHY Link Channel should use the same CP size and symbol duration as the data channel?

- Y: 11
- N: 0
- Abstain: 0

Straw Poll #4

- A CNU will auto-detect the CP size and sub-carrier spacing (symbol duration) of the downstream PHY Link Channel [Not provisioned at CNU]

- Y: 12
- N: 0
- Abstain: 0

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

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%

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 ___

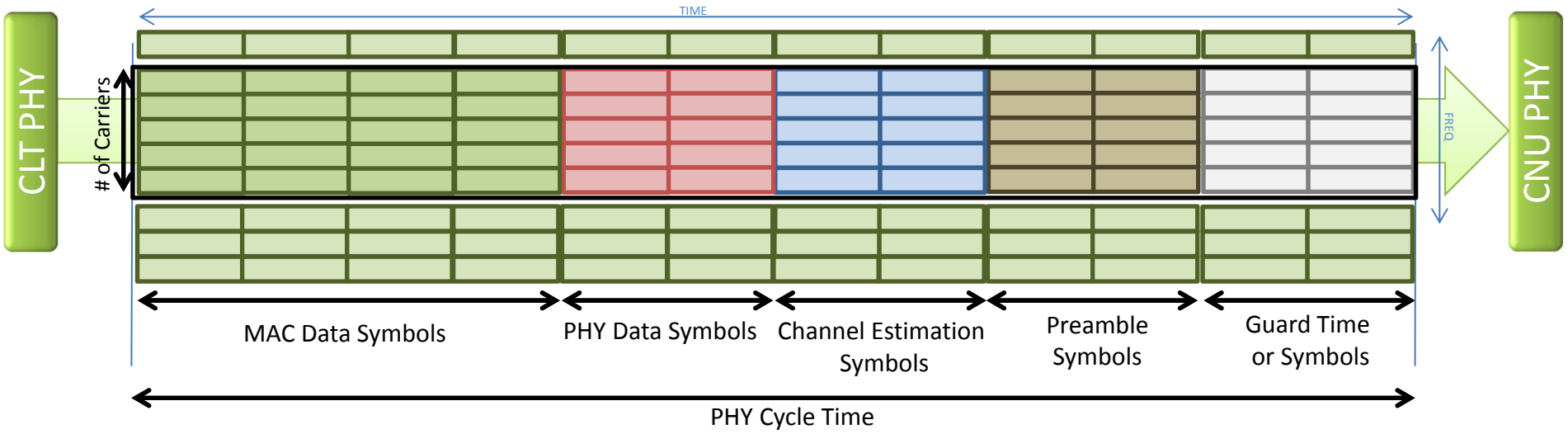
Straw Poll #7

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

Yes ____

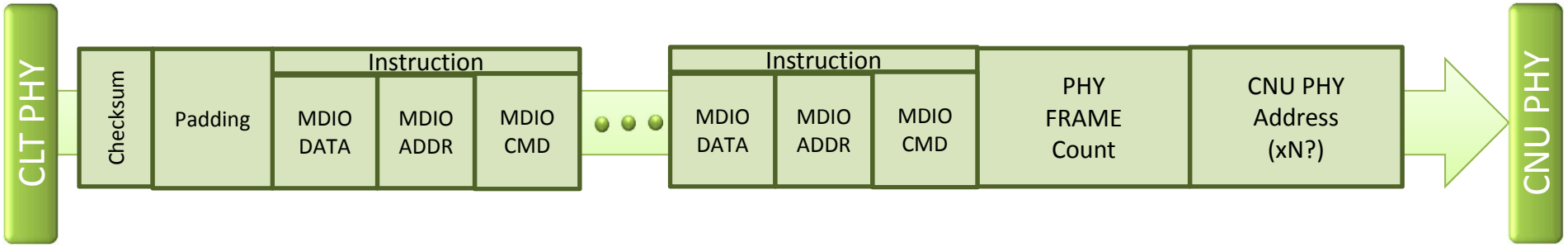
No _____

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				

PHY Link Data Packet (Downstream)



Frame Size	Should we have a fixed size or variable size? Variable size would require a length. 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?

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 (1/16th 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?

Earlier Presentations on Link

REFERENCE MATERIALS