802.3bn Link Ad Hoc

Meeting Notes & Baseline

Agenda, Notes – 10/4/12

- 10am - 11am Pacific
- IEEE Patent Policy Reviewed – Agreed and no known patents
- Attendance Taken – See Attendance slide
- Possible Dates/Times for this meeting – Doodle Poll will be sent out
- Overview – see slides for latest
- Link Topics – see slides for latest
- Parameters & Status Indicators
- Evaluation Criteria

Agenda, Notes – 10/11/12

- IEEE Patent Policy Reviewed – Agreed and no known patents
- Attendance Taken – See Attendance slide
- Implications of PHY Initialization Procedures – Nicola
  - Slides attached at end.
- Added MAC Discovery Compatibility
- Transport Options
  - Added slide with questions for next week and evaluation

Agenda, Notes – 10/18/12

- IEEE Patent Policy Reviewed – Agreed and no known patents
- Attendance Taken – See Attendance slide
- Review questions from last week – See slides for additional answers
- Modified the “Parameters & Status Indicators”
- Link setup Below the MAC - Victor Blake Presentation (20 min)

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

Other Guidelines for IEEE WG Meetings

- **All IEEE-SA standards meetings shall be conducted in compliance with all applicable laws, including antitrust and competition laws.**
  - **Don't discuss the interpretation, validity, or essentiality of patents/patent claims.**
  - **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 – 10/4/12 Conf Call

- Ed Boyd, Broadcom
- Avi Kliger, Broadcom
- Bill Powell, Alcatel-Lucent
- Charley Moore, CTDI
- David Barr, Entropic
- David Law, HP
- Duane Remein, Huawei
- George Hart, Rogers
- Hal Roberts, Calix
- Victor Blake
- Marek Hajduczenia, ZTE
- Mark Laubach, Broadcom
- Nicola Varanese, Qualcomm
- Patrick Stupar, Qualcomm
- Tom Staniec, Cohere Networks
- Kevin Noll, TWC
- Lup Ng, Cortina
- Rick Li, Cortina

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- Steve Shelhammer, Qualcomm
- Avi Kliger, Broadcom
- Victor Blake, Ind Consultant
- Nicola Varanese, Qualcomm
- Patrick Stupar, Qualcomm
- Hesham ElBakoury, Huawei
- Tom Staniec, Cohere Networks
- Michael Peters, Sumitomo
- Ron Wolfe, Aurora Networks
- Rannan Ivry, WidePass
- Chris Pietsch, Qualcomm

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- **Chris Pietsch, Qualcomm**
- **Leo Montreuil, Broadcom**
- **Lup Ng, Cortina**
- **George Hart, Rogers**
- **Brian Kinnard, CommScope**
- **Alan Brown, Aurora**
- **Marek Hajduczenia, ZTE**
- **Dave Barr, Entropic**

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

- TDD or FDD

Downstream Possible List

- 192MHz OFDM Channels Characteristics
  - Cyclic Prefix, FEC, Interleaver, symbol length
- 192MHz OFDM Channels: Available Sub-Carrier
- 192MHz OFDM Channels: Sub-Carrier Modulation Order

Upstream Possible List

- 192MHz OFDM Channels Characteristics
  - Cyclic Prefix, FEC, Interleaver, symbol length
- 192MHz OFDM Channels: Available Sub-Carrier
- 192MHz OFDM Channels: Sub-Carrier Modulation Order
- Transmit Power Level
- Transmit Offset

Evaluation Criteria

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

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?

Earlier Presentations on Link

REFERENCE MATERIALS

Presentation from September IEEE Meeting

SEPT 2012 GENEVA

EPoC PHY Link and Auto-Negotiation

Ed Boyd, Broadcom

Avi Kliger, Broadcom

Marek Hajduczenia, ZTE (Supporter)

Overview & Goals

- This presentation continues the PHY Link & Auto-Negotiation topic from the technical feasibility presentation in Hawaii.
- Like other Ethernet copper PHYs, the EPoC PHY requires a link state machine to configure the PHY before the Ethernet MAC can be enabled.
- The Link process should not require additional signals between the MAC and PHY.
- The Link process should not require EPoC specific changes to the MAC layer.
- The Link process should be very simple and should not require decoding higher layer packets or a complex MAC in the PHY.

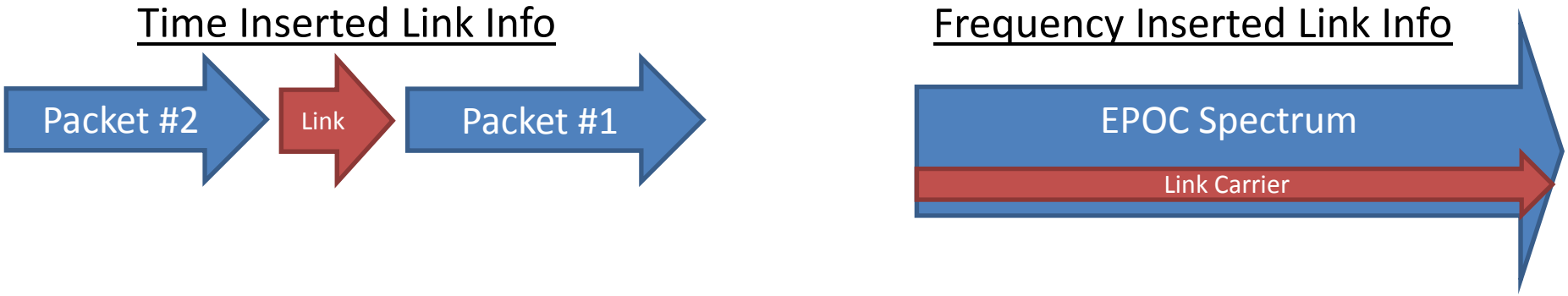
What is Auto-Negotiation and PHY Link?

- Auto-negotiation is a way for 2 PHY's to establish connectivity before the MAC layer has be enabled. (>2 in EPoC)
- A PHY will start out "Unlinked" with the MAC disabled.
- A PHY that has finished auto-negotiation is considered "Linked"
- PHYs will periodically send and receive Link Information.
- If a PHY does not receive Link Information over a time period, it will leave the Linked state and re-start auto-negotiation.
- PHY Link information is a set of configuration parameters sent between the PHYs.
  - PHYs are configured with this information through the MDIO.
- PHY Link information has traditionally been in pages of configuration bits and status indicators.

EPoC Link Information Items

- Sub-Carrier Configuration
  - Location in spectrum, usable/nulled, and modulation order for the carriers in the upstream and downstream.
- Transmit Power Level
- Symbol Alignment Timing Offset
  - Fixed delay offset so upstream symbols are aligned
- Possible PHY Configurations & Capabilities
  - Interleaver Depth/Enable, FEC Type/Size/Enable, Scrambling Enable, etc
- Possible Status Indicators
  - Link State, Rx Power Level, Error Indication, etc
- Possible Future Extensions or Vendor Extensions
  - Power Saving control, link protection, etc

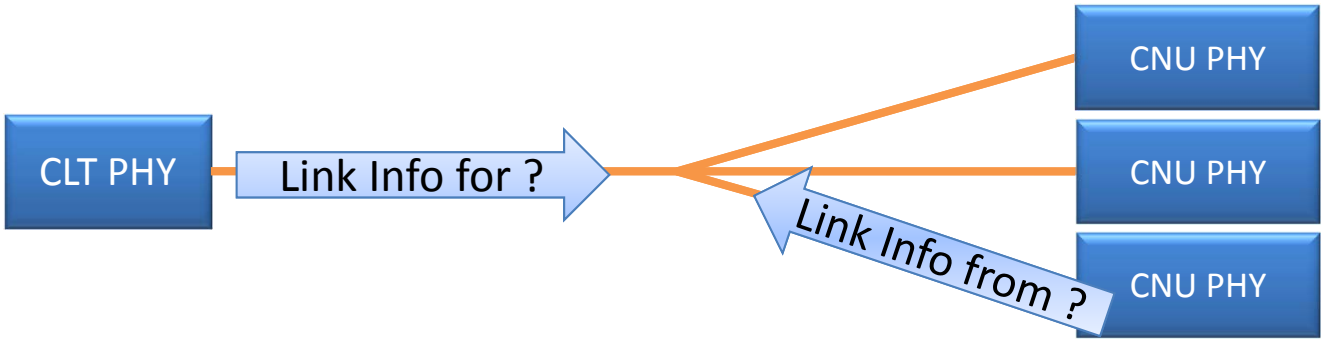
Link Transport Options



- Time Inserted Link Info (Between Packets)
  - Traditionally, Link Info (pulses) have been transported in the IPG.
  - Downstream is challenged by long symbols and streaming FEC so IPG is not possible.
  - Downstream insertion between symbols is possible but complicated.
  - Upstream between symbols or packets would be very difficult without MAC slots.
- Frequency Inserted Link Info (Dedicated Sub-Carriers)
  - A small number of carriers would be dedicated to carry link information.
  - Easy to have a high SNR modulation order for reliability.
  - Coordination with Ethernet MAC for upstream transmission is not required
  - Easier to find and lock onto at discovery.

Frequency Inserted Link Info will be the focus of this proposal

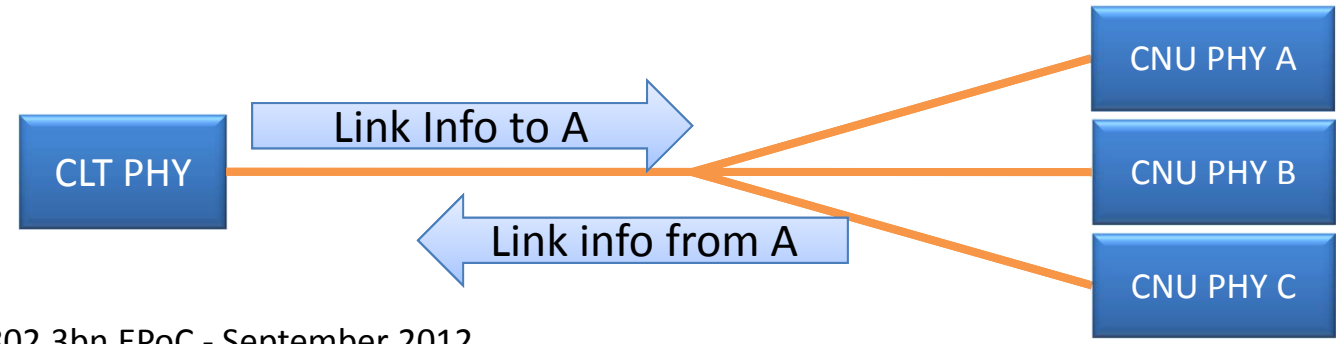
Link Information Addressing



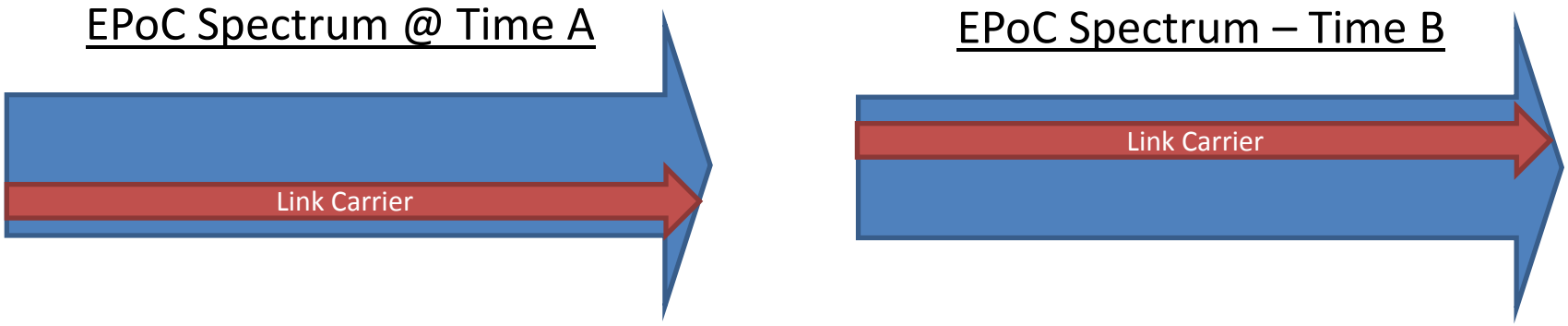
- Point-to-Multipoint Requires an address
  - Traditionally Link Information has been sent on point-to-point network so the source and destination is clear.
  - In the case of EPOC, the CLT needs to send information to a particular CNU.
  - The CLT also needs to know the source of link information that it received.
- What is the address?
  - The address should be the first field in the link information.
  - It can be configured in the PHY through the MDIO
  - The Ethernet MAC address is a possible choice
  - The LLID can't be used since auto-negotiation happens before MAC layer discovery.

Echo Protocol

- Shared Upstream
  - Access to the shared upstream can be simple with an echo protocol.
  - The CLT PHY will simply send the Link Information to the CNU PHY and the CNU PHY will respond with the same message in a fixed time later.
  - A downstream time reference (i.e. MPCP timing from the MAC), GATE frames, etc are not required.
  - The Echo protocol also provides an acknowledge function to the CLT PHY.
- Broadcast Echo
  - Using a broadcast address on the link information allows for a new CNU PHY to be configured.
  - A CNU PHY that has not reached the Linked state, would respond to a Broadcast Echo
  - A random back off in time or Broadcast Echo opportunities should be considered to resolve contention.

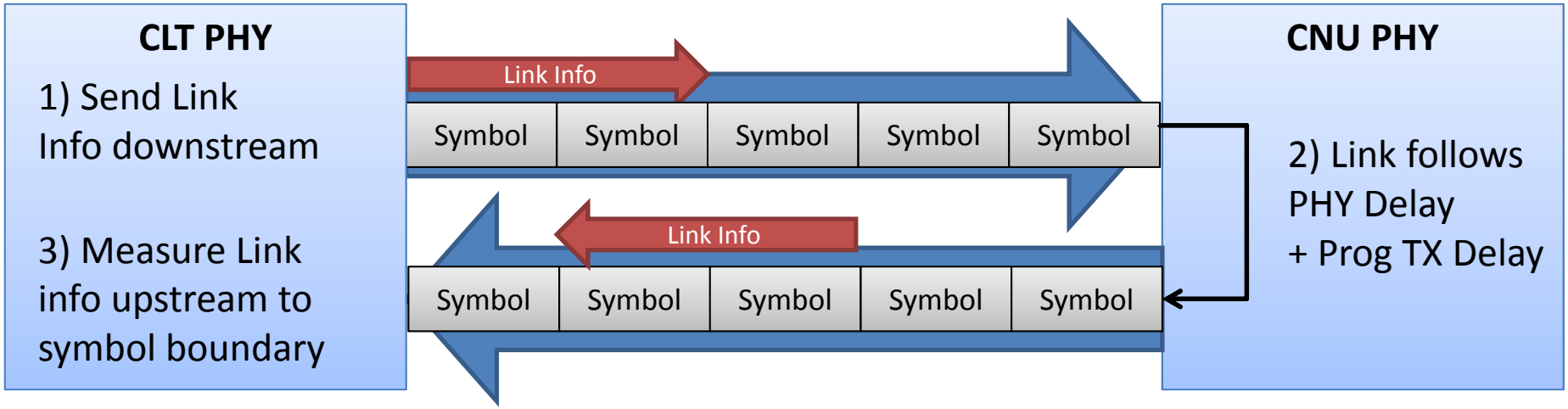


Rotating Link Carrier



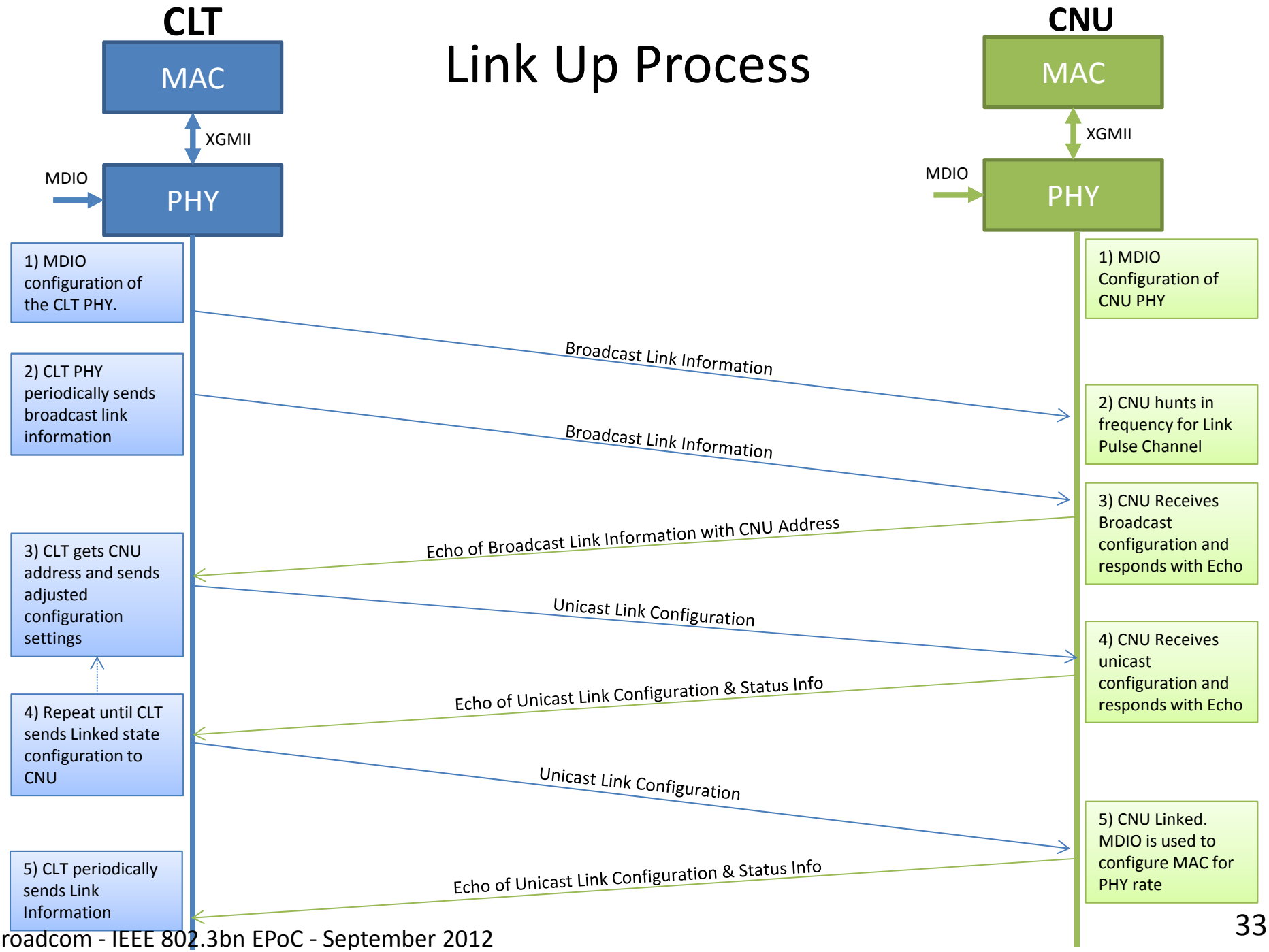
- EPoC Link Carrier could be moved to different carriers periodically so CNUs with interference can register.
- Rotated Link carrier might be used to measure performance or other parameter on all carriers.
- Rotated Link carrier could be applied to upstream or downstream.

Symbol Alignment Example



- CLT PHY needs to align upstream symbols from all CNU PHYs
- MAC grant time selects symbol and carriers in symbol.
- Link Information echo could be used to determine programmable transmit delay.
- Link Information could set value for programmable transmit delay.
- Simple example shows equal upstream and downstream symbols but different sizes could work.

Link Up Process



Summary

- EPoC requires auto-negotiation for the PHY configuration.
- Addressing is required in a Point-to-Multipoint topology.
- Dedicated Carriers make an easy transport for link information.
- The Echo protocol is a simple solution that doesn’t require new MAC signals or any MAC changes.
- We should form an ad hoc group to work on baseline proposal for PHY Link procedure.

Presentation from Link Ad Hoc Call

OCT 4, 2012 CONFERENCE CALL

Implications of PHY Initialization Procedures

Qualcomm – 11 October 2012

PHY Control Channel and Procedures /1

- Need for PHY Control Channel: conveying L1 control information, e.g.
  - Downstream: bit-loading profiles for DS and US
  - Upstream: supported bit-loading profile in DS for a specific CNU

- Coordinated PHY initialization and MPCP registration
  - MPCP is aware of start time of OFDM symbols (PHY framing)
  - Only way to enable bit-loading in US
    - Could use 1D-to-2D map to perform frequency-aware US resource allocation
    - Could use extended MPCP gate message to perform frequency-aware US resource allocation
  - Requires some interaction between MAC and PHY
    - Extensions to MAC/PHY interface ? (additional synch procedure between MAC and PHY)
    - Additional MDIO communication ? (MAC needs to be aware of bit-loading maps)

PHY Control Channel and Procedures /2

- Need for PHY Control Channel: conveying L1 control information, e.g.
  - Downstream: bit-loading profiles for DS and US
  - Upstream: supported bit-loading profile in DS for a specific CNU

- Independent PHY initialization and MPCP registration
  - OFDM symbols and MPCP timing are not aligned
  - This prevents from using bit loading in US: data rate supported by each CNU depends on the frequency resources used to transport its frames
    - This choice forces to use either a single MCS for each CNU or a single MCS for the whole plant
    - In fact, only in this way each CNU would support a fixed data rate no matter on which frequencies its packets are transmitted

The way we do PHY initialization and MPCP registration has a dramatic impact on US system design and MAC/PHY interface !!!

Presentation from Link Ad Hoc Call

OCT 18, 2012 CONFERENCE CALL

Link setup BELOW the MAC

Ideas to noddle on from 3GPP protocol layering
PDP/RLC(channels)/MAC/PLL/PHY

Up and running ?

- How do you establish physical link between CLT and CNU when there are various MCS channels and various MCS per CLT network (domain)?

Assumptions/Limits/Goals

- How do you do so within the limits (goals) set by the project to not modify the MAC and add as little as possible to MPCP (sublayer) ? Continue to assume no buffer in CLT.

Related challenges

a) initial capabilities determination (either discovery or configuration)

b) conveying data rate capability northbound

c) adjusting capabilities if channels or added or if conditions change (rate of change being relatively slow compared to wireless for example). But how “real time” do (a) and (b) need to happen ? If it isn’t fast enough and rates are reduced, obviously frames can be dropped because there is no buffer in the CLT.

Statement and Overview

- Statement

  The objective (here) is not to explain entirely why or how wireless protocols are layered the way they are or how they work. Some of the logic may be for history or backwards compatible reasons, etc.
- Overview
  - Ad Hoc Link objective/problem statement
  - Shared (common) problems to be solved
  - Obviously not exactly the same (what are the differences)
  - 3GPP
    - 3GPP in 20 seconds
    - 2 Transport: SMS/MMS/OMA (datagrams) and PDP tunnels
  - Layering in 3GPP PDP
  - Relationship of transports to various link layers and MAC
  - Ideas for EPoC from 3GPP
- Physical Link Control
  - Where
  - Hidden layers
  - PLC “setup”
  - Recommendations

Shared Problems to be Solved

- Global market has different frequency needs, regulations, etc. around the world
- Desire for single ‘standard’ and single product that works globally
- Varying quality of transmission medium (air/copper)
- Ingressors abound in timescales from perpetual (broadcasters) to persistent to impulse
- History of similar modulation techniques (QPSK, QAM, OFDM, TDMA, OFDMA, SCDMA, etc.) – although notably wireless has always led the way. Of late: OFDM (DS) / OFDMA (US) (look familiar ?)
- Support for both FDD and TDD (Radio resource control isolated from bearer)
- Near/Far (hidden stations); SNR; and other identical problems
- P2MP – aka Many to one; broadcast/multicast and virtual or secured unicast
- Complex P2MP scheduling with changing data rates.
- Similar usage patterns (DS:US ratio), endless demand
- So similar, it’s actually competing for customers using exactly the same services – but that’s another story

Not Exactly the Same

- Unlike wireless, EPoC:
  - Does not have to contend with legacy CPE
  - Fading and other mobile affects obviously not present
  - No mimo and no synchronous broadcast from multiple sources (…Strict synchronous functions are not necessary
  - The time-basis of changes (moves, adds, changes) is on the order of days (not seconds as in wireless)

- So we will not talk about features and functions (in particular specific channels) designed to handle those challenges, instead we will look at the channels used primarily for initial setup and channels used for managing channel assignments

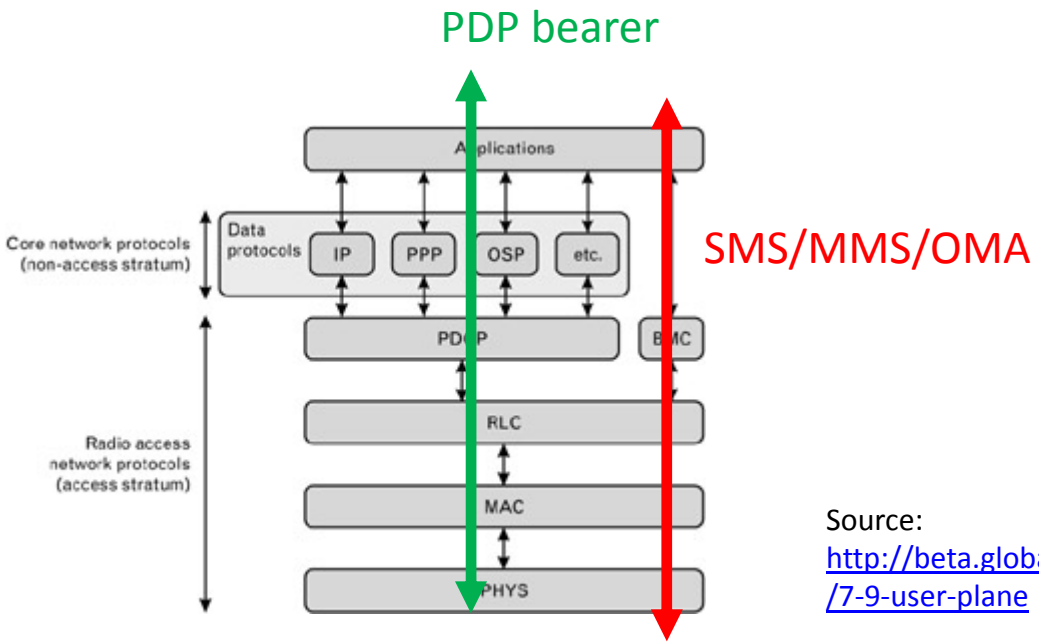
3GPP in 20 seconds

- standards organization for GSM (AT&T & TMO in US)
- developed (for GSM) GPRS which was later adopted by 3GPP2 (sister organization for IMT-2000 and its children CDMA/WCDMA)
- developed LTE, the successor to GSM which still uses the GPRS based architecture
- today, both CDMA and GSM operators with mixed LTE have combined/converged cores that support the GPRS based model for Packet Data Protocol (PDP) transport

Long story short, all cellular wireless
utilize PDP model today

2 Transports

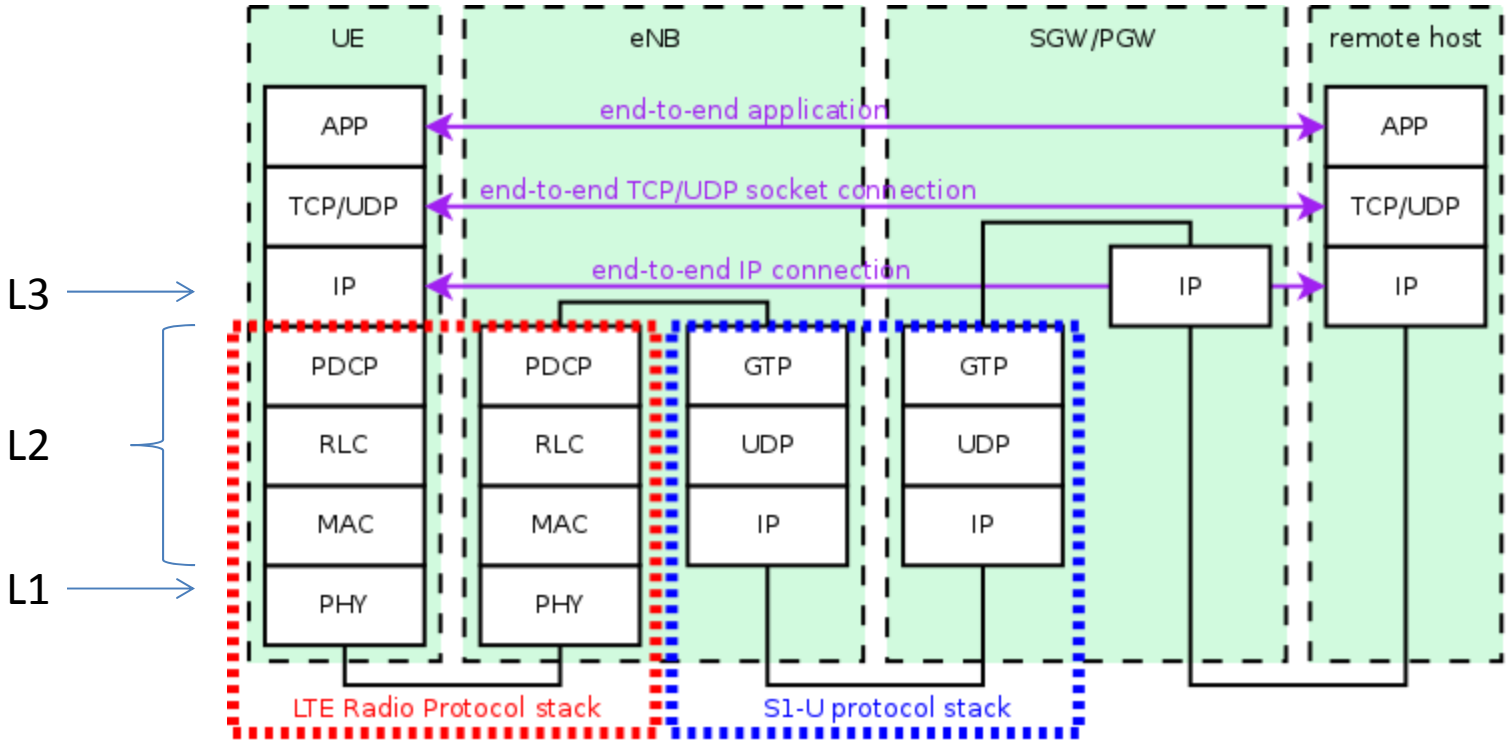
- There are classically two transport systems within cellular. These are the circuit switched (CS) and packet switched (PS) domains. Within each or combined between the two are both signaling and the bearer networks. The signaling network was co-opted to be a bearer network as well, for messaging (at first SMS, then MMS, and now of course OMA which integrated the latter two and datagram based transport for IP that doesn't require bearer "setup". Both are shown here in this WCDMA example.



Source:
http://beta.globalspec.com/reference/65882/203279/7-9-user-plane

- We will look only at the PS domain, and within it the layering to provide the Packet Data Protocol (PDP) PS bearer.

LTE non-message bearer (PDP)



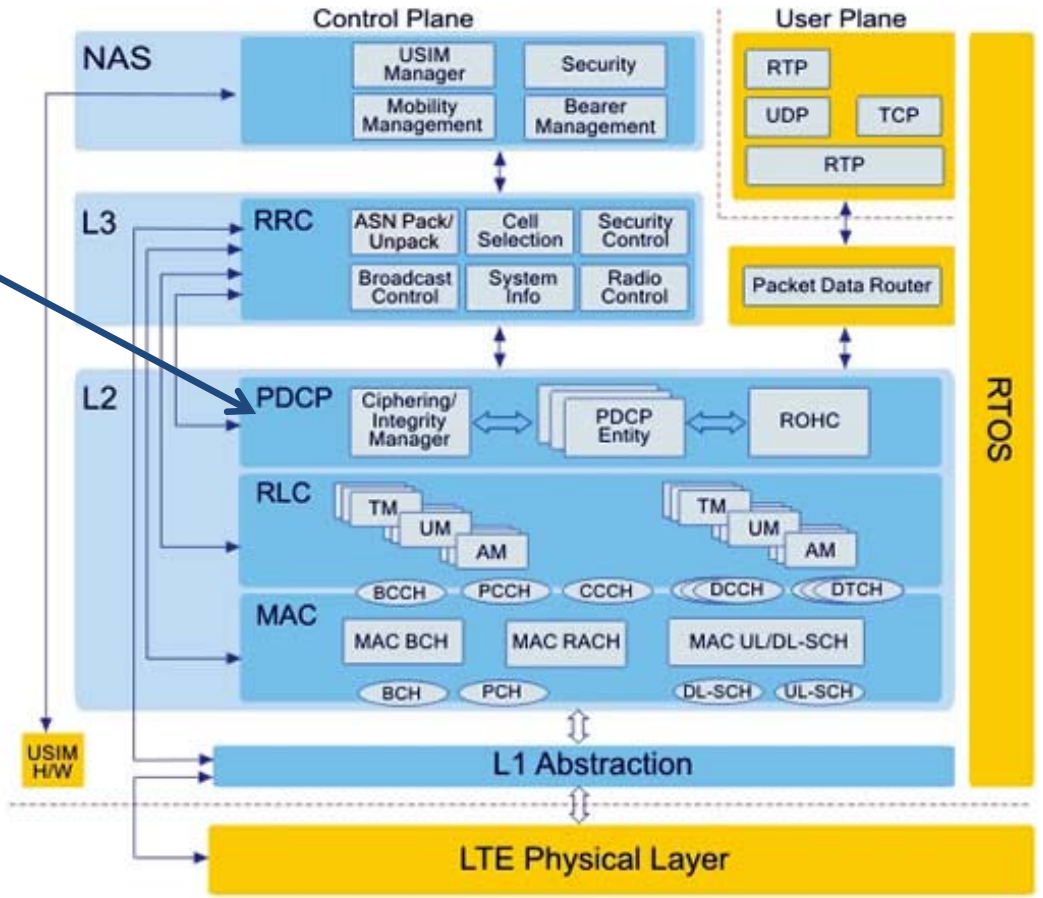
Source: http://www.nsnam.org/docs/models/html/lte-design.html

Other variations use GRE/PPP/IPsec for one or another of PDP bearer or signaling. Important point is that while there are many layers, PDP looks like a link layer to the OSI network layer. That's what I'd like us to look at.

RLC function

Here PDP is depicted as a link layer even though it resides far above the MAC. You can think of each PDP context as analogous (for example) to a DOCSIS service flow (SF).

I'm not suggesting we do this as shown, bear with me …

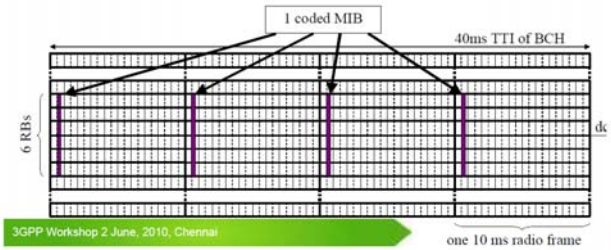


Source: Rhode and Schwarz
(apologize that I don't recall which R/S document this came from).

DL Signaling in PHY (PBCH)

Cell acquisition signalling

- Synchronisation signals in subframes 0 and 5 of each 10 ms radio frame
  - Used in initial cell search
- Physical broadcast channel (PBCH) in subframe 0 of each radio frame
  - Carries the Master Information Block (MIB)
    - Includes indication of system bandwidth
  - Robust design for cell-wide coverage:
    - Low rate, QPSK, robust channel coding (1/3-rate tail-biting convolutional code with repetition), 40 ms TTI
- CRC indicates number of transmit antennas



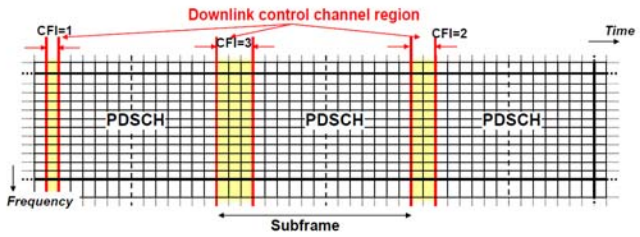
Modes …

PDSCH transmission modes

- In Rel-9, each UE is configured in one of 8 "transmission modes" for PDSCH reception:
  - Mode 1: Single antenna port, port 0
  - Mode 2: Transmit diversity
  - Mode 3: Large-delay CDD
  - Mode 4: Closed-loop spatial multiplexing
  - Mode 5: MU-MIMO
  - Mode 6: Closed-loop spatial multiplexing, single layer
  - Mode 7: Single antenna port, UE-specific RS (port 5)
  - Mode 8 (new in Rel-9): Single or dual-layer transmission with UE-specific RS (ports 7 and/or 8)
- (in each case, transmit diversity is also available as a fallback)

Downlink Channel Structure

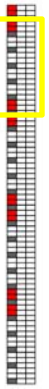
- Flexible control design to avoid unnecessary overhead
  - Control region is first 1-3 OFDM symbols in each subframe (2-4 in narrow bandwidths)
  - Control region size (CFI: control channel format indicator) is dynamically variable
- Data transmission on Physical Downlink Shared Channel (PDSCH)



Location of control signaling …

Downlink control signaling

- Physical Control Format Indicator Channel (PCFICH) indicates the control region size (CFI)
  - Located in first OFDM symbol of each subframe
  - PCFICH is designed to be robust
    - 16 QPSK symbols transmitted with full frequency diversity
- Physical Downlink Control Channel (PDCCH) carries Downlink Control Information (DCI) messages:
  - downlink resource assignments
  - uplink resource grants
  - uplink power control commands
- Physical Hybrid ARQ Indicator Channel (PHICH) carries ACK/NACK for UL data transmissions



Source: http://www.3gpp.org/ftp/Information/presentations/presentations_2010/2010_06_India/3GPP%20LTE%20Radio%20Physical%20Layer%20%28India%29.pdf

Ideas for EPoC from 3GPP

- Accommodate various MCS (TDD, FDD and frequency plans)
- DL Broadcast matrix on symbols for client channel use (modes in 3GPP)
- Random access UL channel
- Hidden layers (we already use this)
- Physical Channel “Indicator” provide signaling to higher layers

Layering in 3GPP

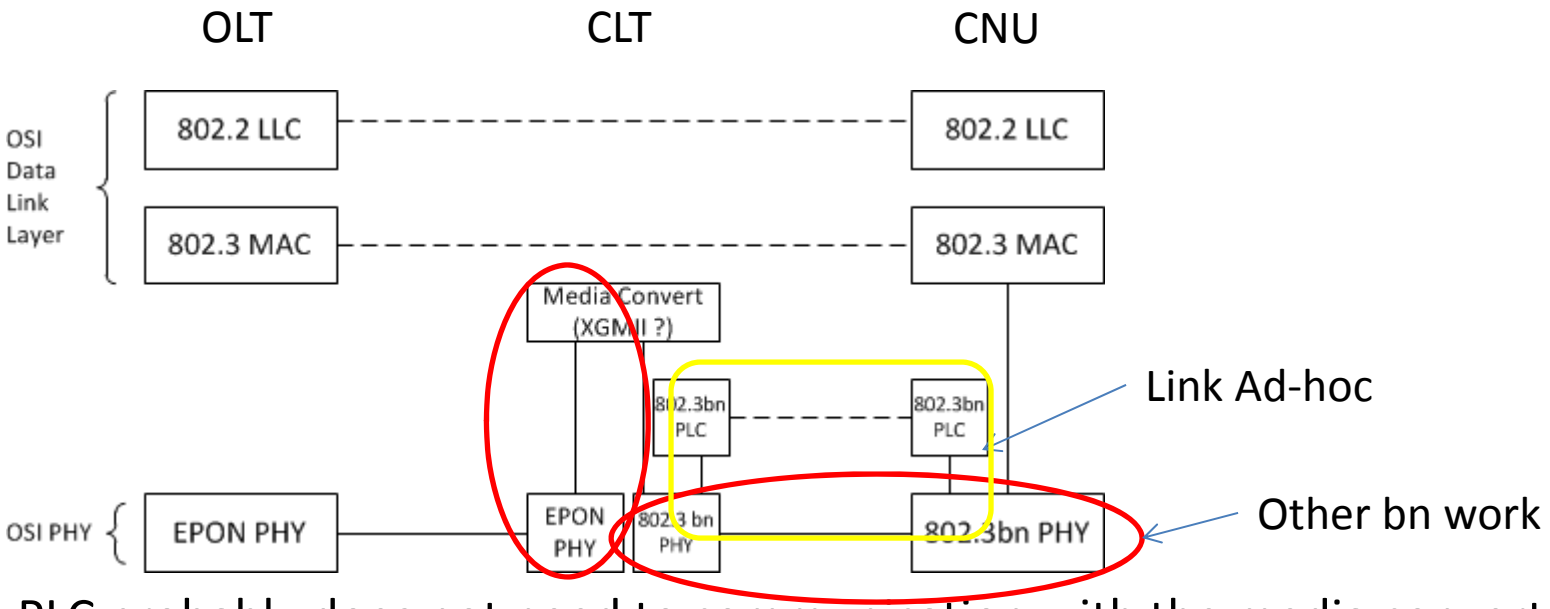
- Two ways to look at 3GPP layering:
- Look at the labels:
  - PDP (carries GTP) is below the network but above the LLC. Kinda like MPLS, a tunnel logical link forwarder
  - RLC is LLC
  - MAC is MAC
  - PLL is new, we don't have this in 802
- Look at the functions:
  - IP is network (Layer 3)
  - PDP is LLC (Layer 2)
  - RLC is multiplexing layer (like DOCSIS channel boding M-PPP/L2TP)
  - MAC SCH within MAC is like MPCP
  - PLL is obviously below the MAC
- For our purposes, two areas of interest to learn from

1) Link Control
   1) Looking at the PDP as if it were LLC, what we see below it is a link control layer (RLC) with possible **lessons to learn regarding fixed use of resources within a logical channel (and underlying physical channel) to create permanent logical-logical channels for physical link layer resource management and control (channel selection, etc.)**.
2) PHY Control
   1) Looking at the MAC-SCH/PLL what we see is a **mechanism for signaling PHY information to higher layers (indicators)**
   2) **Predetermined symbols broadcast frames at well-known (time referenced by prefix) 'locations' include matrix of information. That information (MIB) further contains supported modes, etc.**

Learning from 3GPP

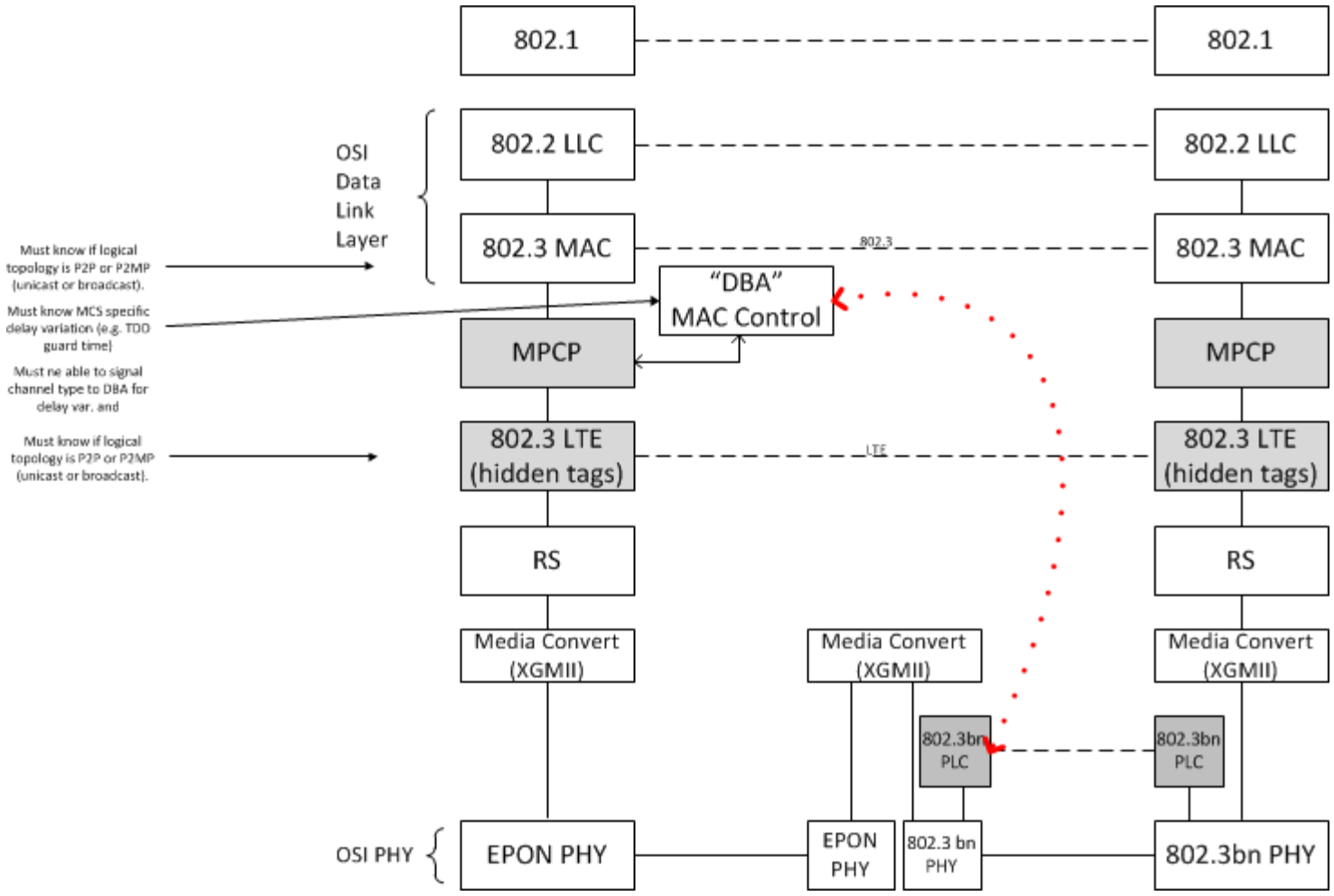
- SIB/MIB video http://www.youtube.com/watch?v=_P4j5Kn8HCc
- 3GPP Specifications
- R&S http://www2.rohde-schwarz.com/file_17282/1MA191_0E.pdf

Physical Link Control (PLC): Where



- PLC probably does not need to communication with the media converter US
- CLT has integral ONU to receive EOAM from OLT to setup profiles
- CLT originates profile broadcasts directly to PLC
- CNU knows which profiles to use and begins using them PHY without PLC response
- Summary: PLC is one way (broadcast) CLT-> CNU phy link to be used to setup channels.

Closer Look at the Hidden layers



“Link” Setup

- Establish the concept of Physical Link Layer or Physical Link Control (PLC)
- Physical Link Control
  - Modeled in part after PRACH (async initial setup) and in part after PBCH (which carries master block or MIB)
  - DS: Supports only fixed length frames of specific types
    - Announce: broadcast profiles (both DS and US)
    - ACK channel ?
  - data rate can be low
  - operate on LCD frequency/modulation. All CLTs and CNUs must support this
  - not visible to the MAC, there is no data path transmission over PRACH CLT broadcasts ‘MCSes’ (These are called “modes” in 3GPP, I prefer to call them profiles see below).
  - Requires either regular broadcasts for new stations (CNUs) to find
  - Probably forced
  - US requires further discussion
    - If CNUs are only going to support a subset of profiles, does it matter which ones ? They really don’t need to respond to DS PLC, just use it. Ex:
    - If A B C D E are available, but administrative PLC only offers A C E, then we just say CNU MUST NOT use B or D. Let’s say then that CNU uses A or C or both. It does not HAVE to tell the CLT over “PLC” because when it begins transmitting on A and/or C, CLT will know
    - Options (I don’t think these are needed)
      - Could require CNU to transmit ack type pdu on A or C across PHY to MPCP, does not require transmission on PLC channel
      - Could follow-up PLC announce, ack on A/C and then ack on PLC ?
      - May not require US for PLC at all ….

“Link” Setup

- Profiles consist of administratively permitted MCS combinations and can be both technical and policy based. Example use of profiles:
  - MCS A B C D E part of the spec
  - Operator chooses to support A C E
  - CNU Model 1 support A C
  - CNU Model 2 supports A E
  - Operator profiles possible:
    - A only
    - C only
    - E only
    - A / C
    - A / E
    - C / E
    - A / C / E
- Each MCS could support various rates or channel widths. Not sure if the variations with MCS would be handled as a subset of these (like A1, A2 or A:f1, Af2, etc.). Leave that to the spectrum team…

“Link” (PLC) Requirements/functions

- DS (DL)
  - CLT Must encode profiles into predetermined matrix
  - CLT assumes the MAC is up and running even when there are no CNUs connected. For this to work CLT must always be transmitting matrix
  - CLT Transmit must not be (AES) encrypted
  - CLT Transmit must be on permanently assigned symbol combinations
  - CLT PLC matrix is broadcast to all logical terminals (LTE hidden tags)
  - Would not not need ACK (HARQ in 3GPP) if we continuously re-transmit
- US (UL)
  - US random access channel information is included in information on PLC (equivalent of 3GPP master information block MIB)
  - US random access channel size is dependent on two #s:
    - Domain size (# of CNUs)
    - Frequency of changes expected
    - Resulting calculations will determine the probability of a failed access attempt (detectable only by the CLT) from a ‘collission’. Larger channel, lower probability of collision.
    - Less frequent changes announced, less frequent changes of CNUs to different profiles
  - Do we need a PLC UL mechanism ? (I would say no we do not need this)
  - Does the CNU just listen to DS and then begin registration on a designated random access UL channel LEARNED from that information ?

- Number of symbols (effective logical use of physical channels depends on logical channel sizes and bw needed to transmit matrix). That in turn is largely dependent on the number of CNUs