

EPoC PHY Link and Auto-Negotiation

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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.

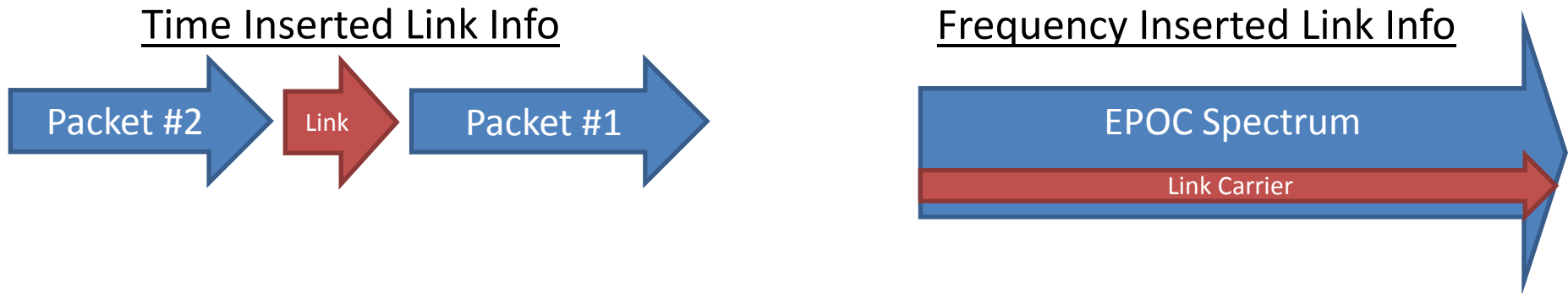
What is Auto-Negotiation and PHY Link?

- Auto-negotiation is a way for 2 PHY's to establish connectivity before the MAC layer has been 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

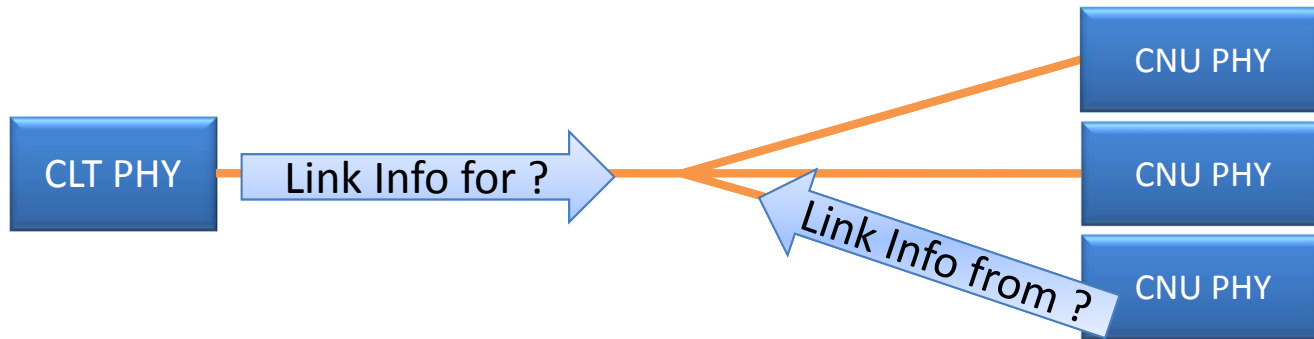
Link Transport Options



- 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

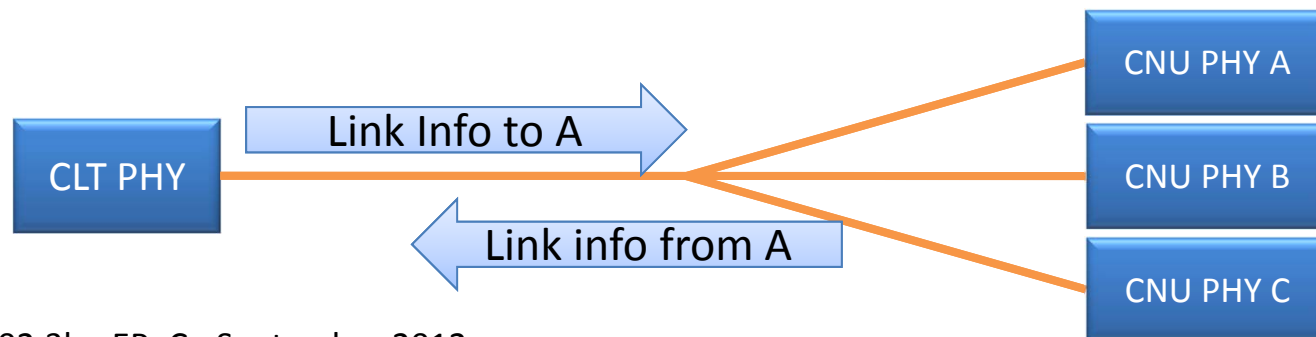
Link Information Addressing



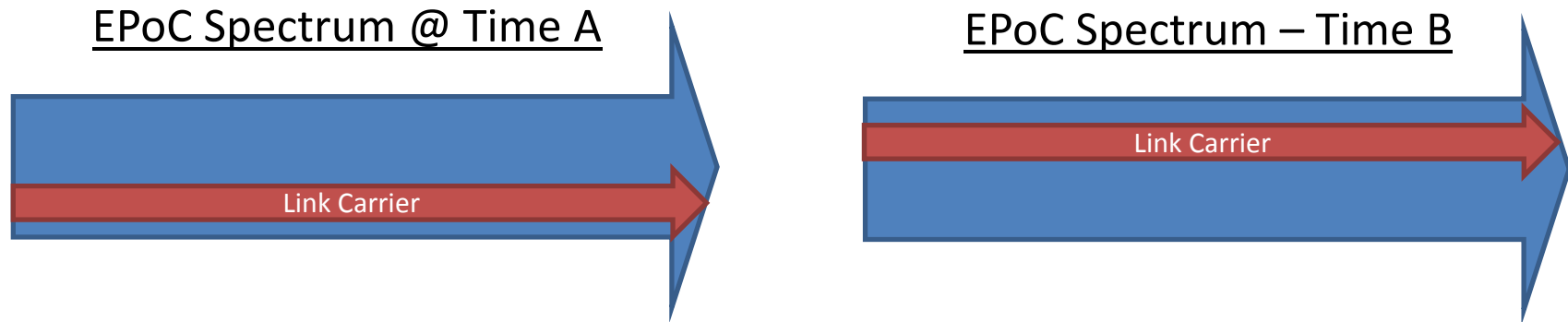
- Point-to-Multipoint Requires an address
 - Traditionally Link Information has been sent on point-to-point network so the source and destination is clear.
 - In the case of EPOC, the CLT needs to send information to a particular CNU.
 - The CLT also needs to know the source of link information that 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.

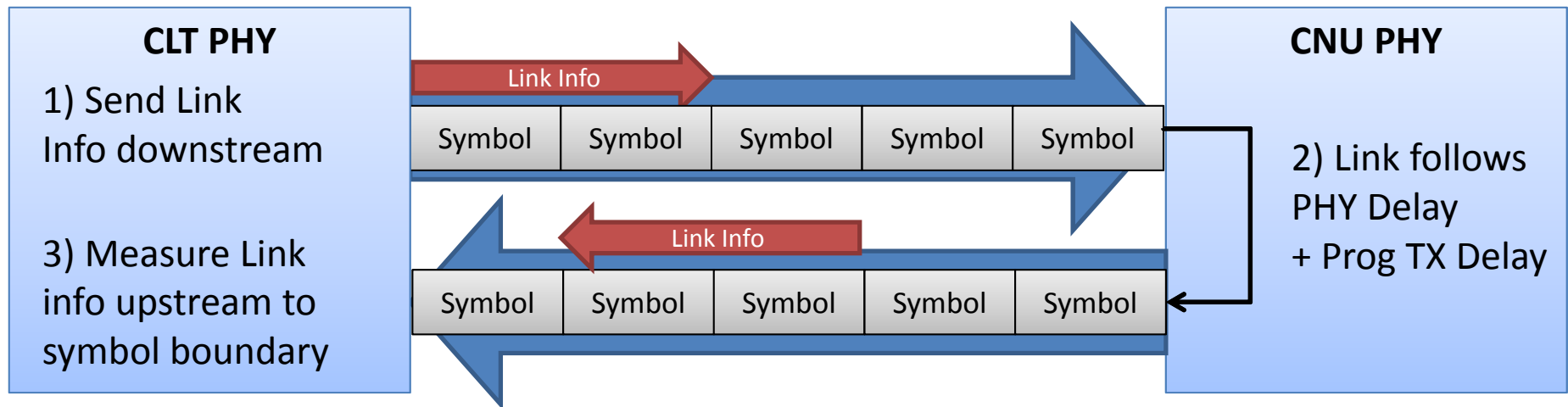


Rotating Link Carrier



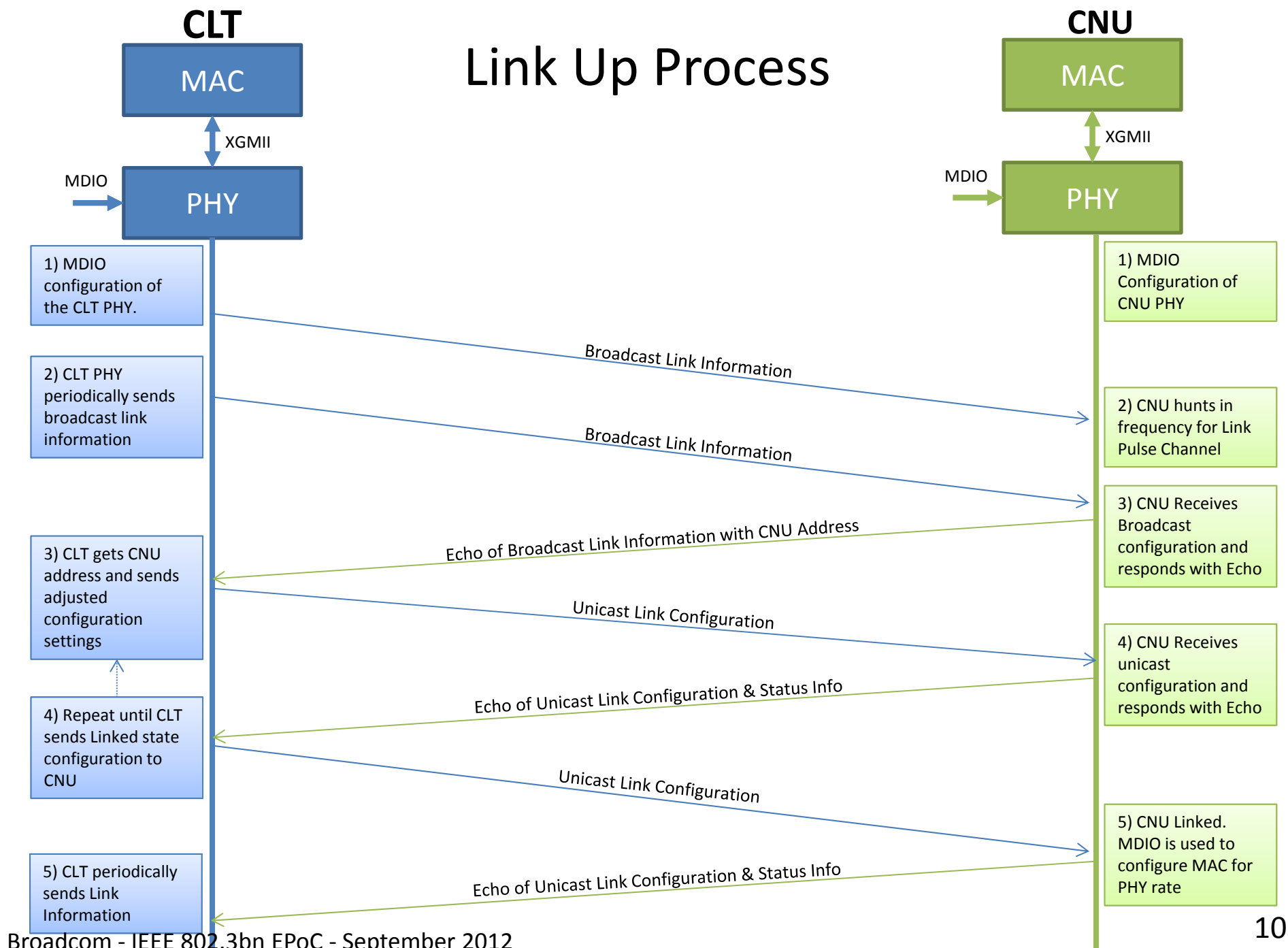
- EPoC Link Carrier could be moved to different carriers periodically so CNU's with interference can register.
- Rotated Link carrier might be used to measure performance or other parameter on all carriers.
- Rotated Link carrier could be applied to upstream or downstream.

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.