

IEEE P802.3da: 10 Mb/s Multidrop Enhancements Overview for E-PLCA SG

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What's 802.3da all about?

802.3da STARTS with 10BASE-T1S (Cl. 147)

Multidrop (shared-media) half-duplex 10 Mb/s Ethernet introduced in 802.3cg

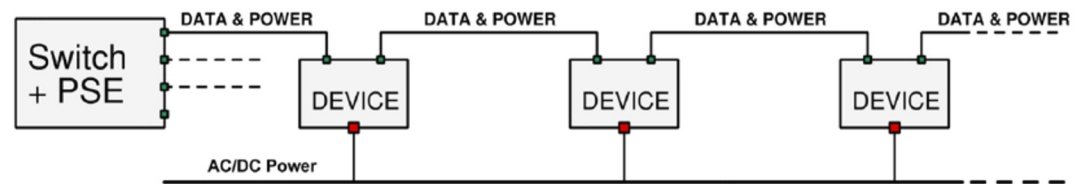
Designed for ‘engineered’ harnesses as the mixing segment

- Vehicles, backplanes, inside engineered equipment

802.3da develops enhancements to make it more ‘plug-and-play’

- Suitable for buildings and larger systems

Multidrop Automation



- Many of today’s industrial and building automation systems use multidrop topologies for data or data+power.
- Data+power
 - High power devices use bus power for the control system, AC or DC to power the main load.
 - Low power devices use bus power only.
- Moving to Ethernet (incl. Ethernet diagnostics), will significantly improve user experience and network value

10SPE Multidrop Enhancements CFI deck. Julv 2019 Vienna. Austria

8

10BASE-T1S Physical Layer has 3 parts

PHYs: 10BASE-T1S 10 Mb/s half-duplex PHY (Clause 147)

- Differential Manchester Encoded (DME), 4B5B encoded half-duplex Ethernet
- Does not specify power, but allows for it by specifying voltage tolerance of PHYs

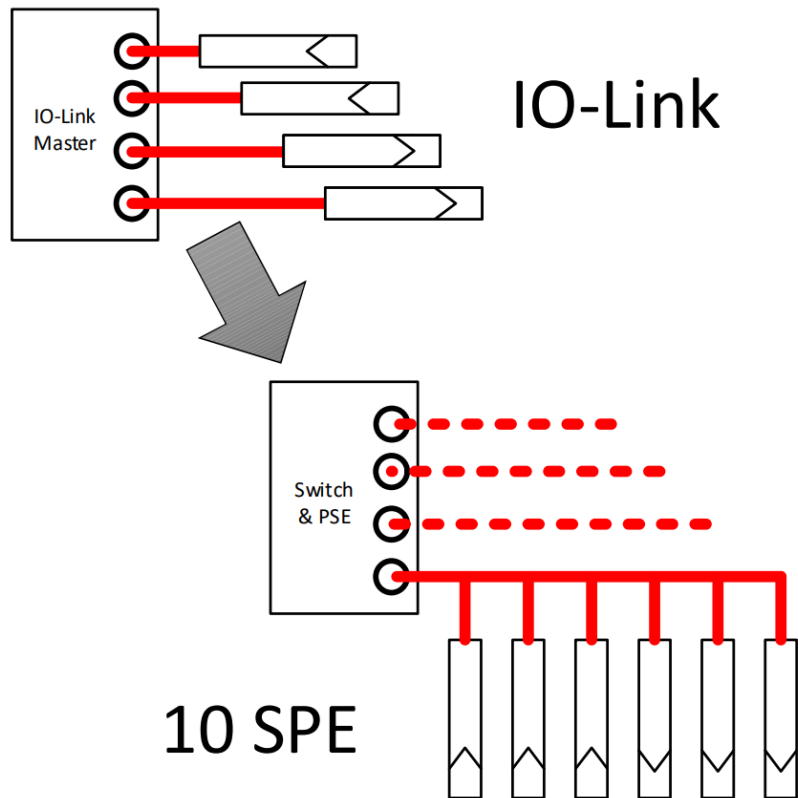
Mixing Segment Wiring (147.8):

- Specified for insertion loss and return loss *at each MDI attachment point*

Reconciliation Sublayer (Clause 148):

- Clause 148 PLCA “Physical Layer Collision Avoidance”
- Uses CSMA/CD MAC together with a management-assigned “Node ID” and a designated “coordinator” to avoid collisions by adhering to Transmit Opportunities

Plug-and-Play Multidrop: Enables Industrial Network Simplification



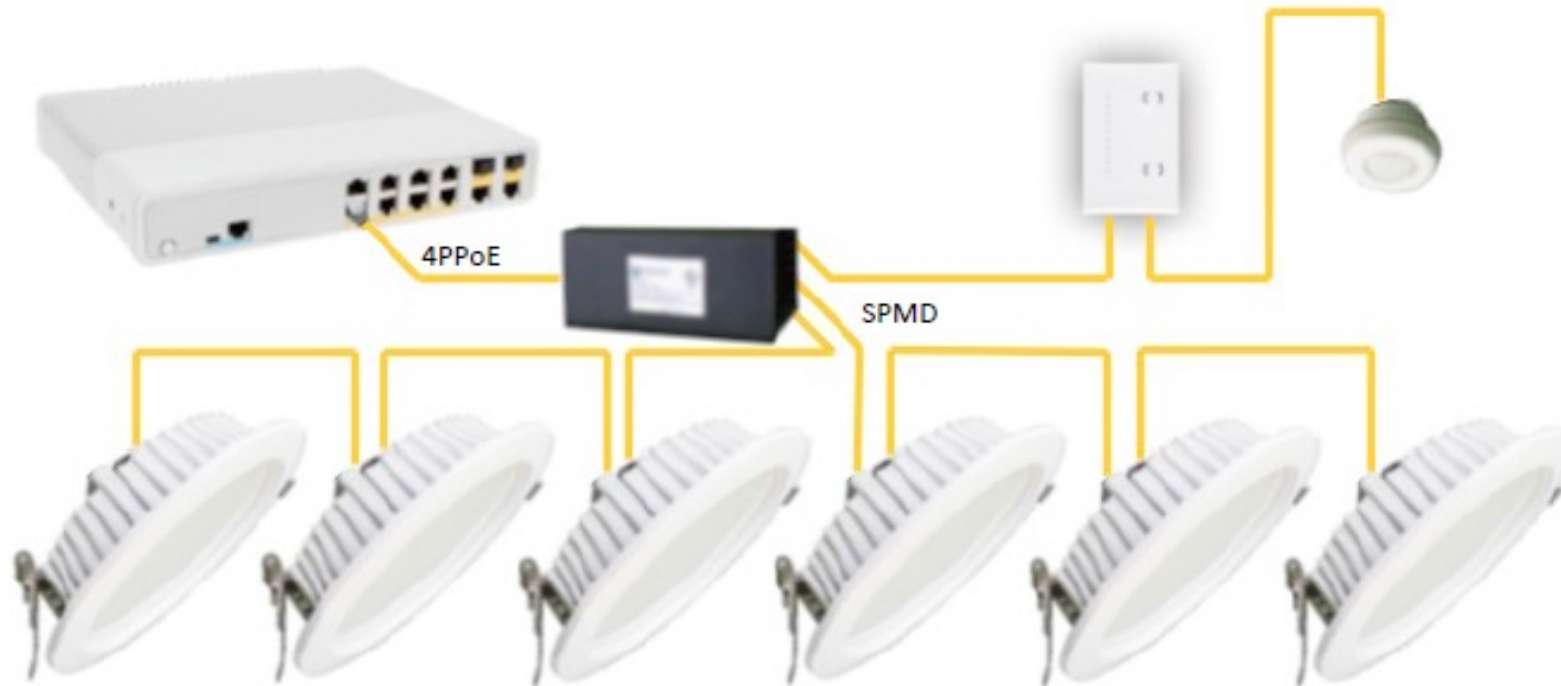
Simple sensors often come in M8/M12 housing (threaded rods with a longitudinal hole) with as little as 5mm in diameter on the inside



https://www.ieee802.org/3/SPMD/public/sep19/spmd_pohl_01_0919.pdf

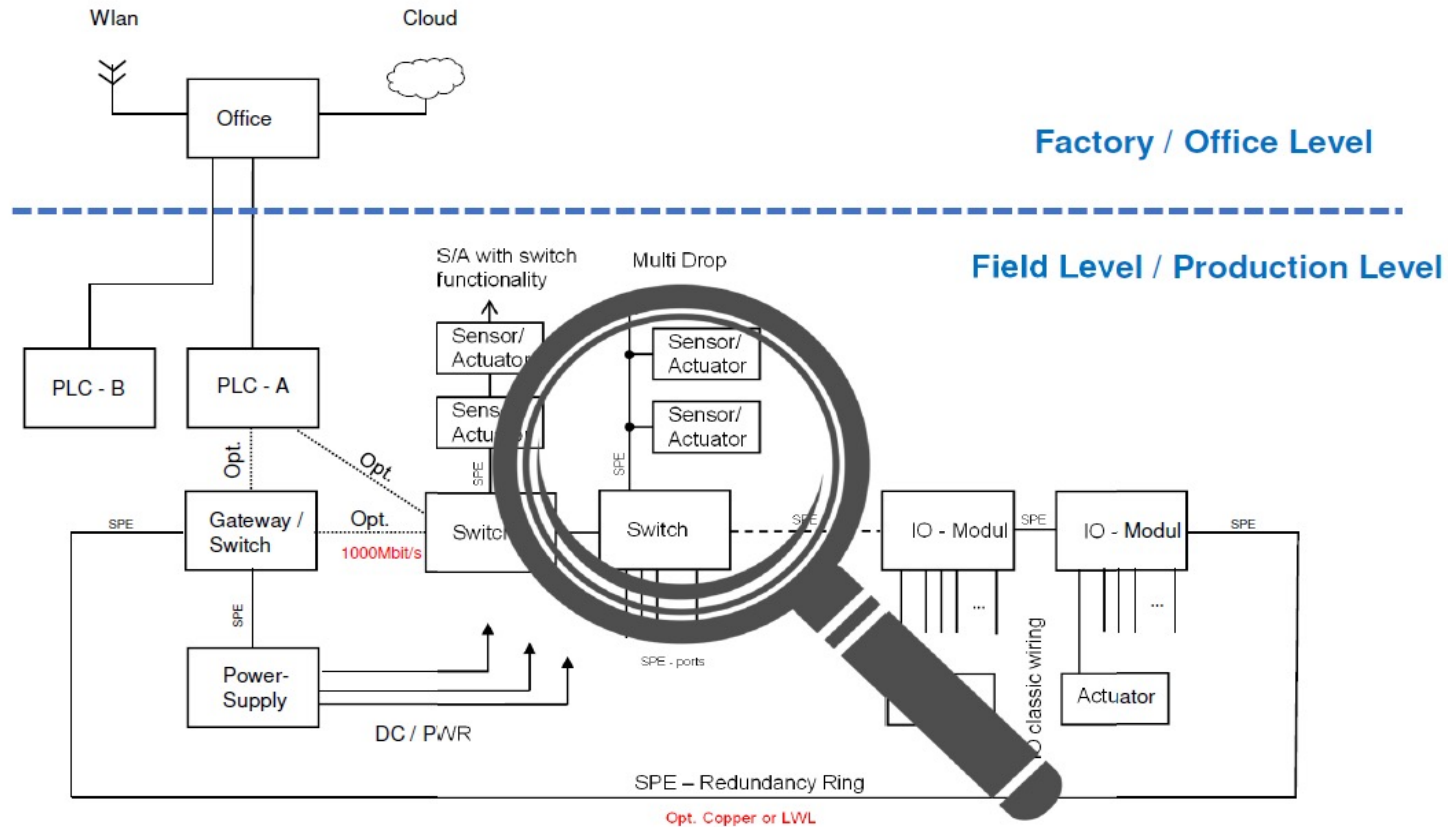
Multidrop simplifies node-based Ethernet lighting

Node Based Lighting Solution



https://www.ieee802.org/3/SPMD/public/dec1819/SPMD_Usecase_node_based_lighting.pdf

Multi-drop fits sensor networks



https://www.ieee802.org/3/SPMD/public/dec1819/SPMD_Usecase_Train_industrial_Sensor_CE.pdf

IEEE 802.3da Multidrop Enhancements: High Level Overview

Enhancements related to 10 Mb/s Multidrop SPE introduced as 10BASE-T1S in IEEE P802.3cg, in 5 easy pieces:

- **No New Device:** Half duplex operation, 10 Mb/s, shared media PHYs, backward compatible with Clause 147 10BASE-T1S – SAME PHY as Multidrop mode
- **More Plug-and-Play Wiring:** Improved specifications for the mixing segment and interface from the device to the wiring
- **Mixing Segments for buildings:** 50m reach more nodes
- **Self-configuring PLCA:** D-PLCA removes the need for management to configure node IDs on the mixing segment
- **Powering for multidrop:** Detect/classify, provide power only when needed

What's in the PHY?

10BASE-T1M: 10BASE-T1S (Cl 147) but ONLY Multidrop

Half-Duplex Multidrop with support for collision avoidance (PLCA from 802.3cg)

Same 4B/5B PCS as Clause 147

- No point-to-point only functions, like heartbeat or Link Monitor

Same DME Encoding and timing

Same PMA with some refinements:

- Refinement of Test Fixtures to work at new “TCI” line interface
- Tightening of lower transmit PSD mask to improve interoperability

Expectation is 10BASE-T1S multidrop PHY Silicon (PCS/PMA) will meet 10BASE-T1M requirements

New MDI specifications “Trunk Connection Interface” are outside the PHY chip

What is this new powering scheme?

THIS PART OF 802.3da SHOULD HAVE NO BEARING ON E-PLCA



High-level description of MPoE

Defines an MPSE and an MPD (similar to a PSE and a PD in PoE)

Generally only one MPSE per mixing segment

- More than one MPSE isn't disallowed, but is out of scope

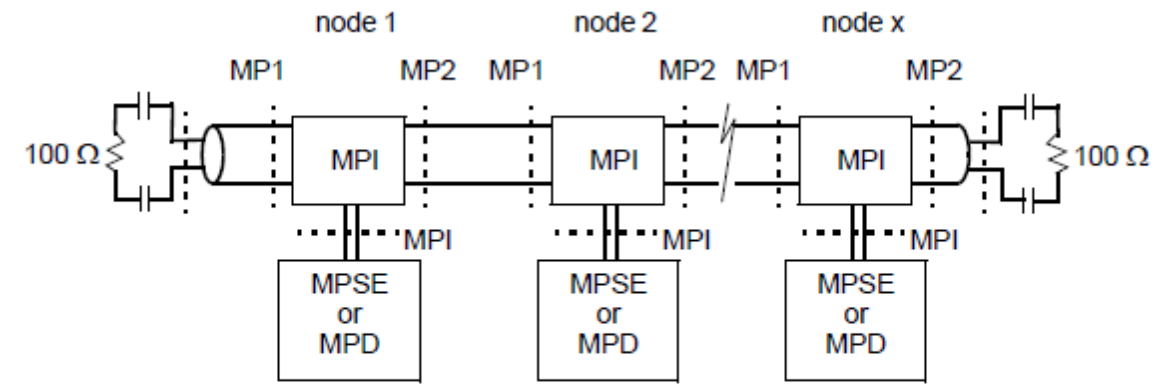
Can have one or more MPDs on the wiring

- PSE provides no power until at least one MPD is detected

Devices on the mixing segment may or may not take power (supports non-MPDs)

Defines the MPI (Multidrop power interface) which can be the TCI (data interface)

Defines unit loading for MPD power consumption



NOTE – The MPI may not be exposed. If it is not exposed, specified values are calculated from values observed at MP1 and MP2.

Figure 189-1—Mixing segment and reference points for power

THIS IS THE PART THE
MATTERS TO E-PLCA

What is D-PLCA?

D-PLCA Allocates PLCA node IDs

PLCA works by assigning “transmit opportunities” to nodes based on a node ID (local to the mixing segment)

- PLCA is interoperable with CSMA/CD nodes

PLCA node IDs are assigned by the management entity – outside the scope of clause 148

- Plug-and-play networks would like these IDs assigned automatically.
- Also would like “coordinator” assigned automatically

802.3da adds an optional functionality to Clause 148, D-PLCA, to “Specify an optional PLCA node ID allocation method” (Objective 3)

BUT FIRST....

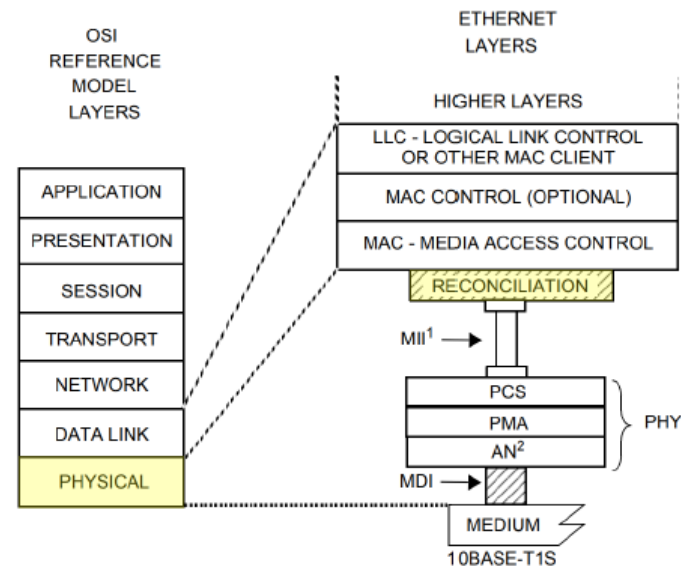
What is PLCA?

Where does PLCA fit?



Introduction

- PHY-Level Collision Avoidance is an optional Generic Reconciliation Sublayer (gRS) defined in clause 148.
- It's meant to improve CSMA/CD performance (throughput, latency, fairness) for multidrop, mixing-segment networks featuring a low number of nodes and high bus loads.
 - Not a replacement of CSMA/CD → PLCA actually relies on CSMA/CD functions
 - Not a replacement of TSN → TSN is expected to work on top of PLCA
- Working principle is to dynamically create transmit opportunities to avoid physical collisions on the line.
- Can be seamlessly switched to/from plain CSMA/CD
- Supported by 10BASE-T1S PHY (Clause 147) operating in multi-drop mode over mixing-segment.



Public Document

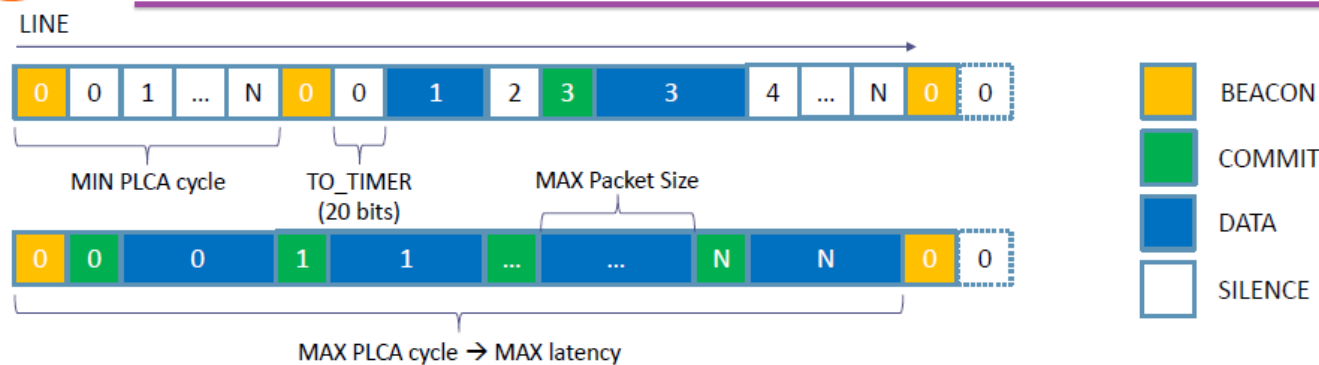
canovatech
The Art of Silicon Sculpting

<https://www.ieee802.org/3/cg/public/July2018/PLCA%20overview.pdf>

What is PLCA?



PLCA in a nutshell



- PHYs are statically assigned unique node IDs [0..N]
- PHY with ID = 0 is the head node (PLCA coordinator)
 - Sends BEACON to signal the start of a PLCA cycle and let other PHYs synchronize their transmit opportunity timers
- Max latency is guaranteed to always be less than one PLCA cycle
- Round-robin scheduling provides fairness
- A PLCA cycle consists of one BEACON and N+1 transmit opportunities, allowing up to N+1 **variable size** packets to be sent
 - PHYs can start a transmission only during the transmit opportunity which number matches their own node ID
 - A new transmit opportunity starts if nothing is transmitted within TO_TIMER or at the end of any packet transmission
 - PHYs are allowed to transmit COMMIT during their transmit opportunity to compensate for any MAC latency (e.g. IPG) before transmitting a packet

Public Document

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<https://www.ieee802.org/3/cg/public/July2018/PLCA%20overview.pdf>

What does 'classic' PLCA require?

Interaction of Clause 4 (half-duplex) MAC, MII signaling, and PLCA RS state diagrams

- Tracking all of these makes it hard....

Assignment of node IDs (and number of transmit ops) by management

Assignment of a 'coordinator' node to send out the BEACON

D-PLCA was introduced to eliminate the setup by management...

How D-PLCA works

Look for “stolen” Transmit Opportunities (TOs)

- Detecting that a node is transmitting during another’s TO
 - Accomplished by detecting commit

Each node keeps a list of used TOs, and frees them up with an aging criterion

Each node grabs a transmit ID after listening to build a table based on what is used

- Grabs another if that one wasn’t actually free

Nodes that want “coordinator” role similarly monitor beacons

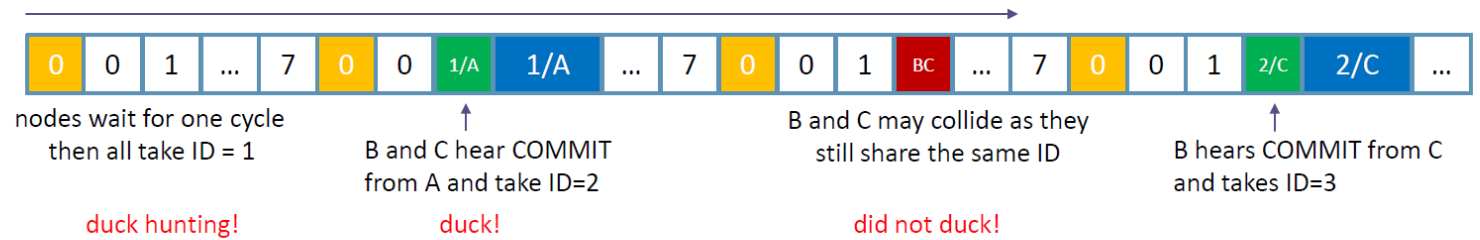
See: https://www.ieee802.org/3/da/public/0321/beruto_3da_01_031021.pdf

Example of nodes finding an ID

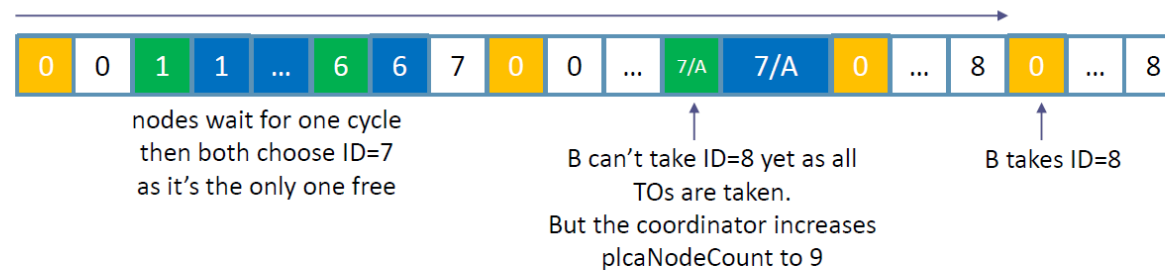
See: [From: beruto 3da 01 031021.pdf](#)

Example: join of nodes

3 nodes (A, B, C) want to join, coordinator already selected, initial plcaNodeCount = 8



2 nodes (A, B) want to join, currently 7 on the network, initial plcaNodeCount = 8



Example of election of coordinator

See: [From: beruto 3da 01 031021.pdf](#)

Example: election of coordinator (localNodeID = 0)

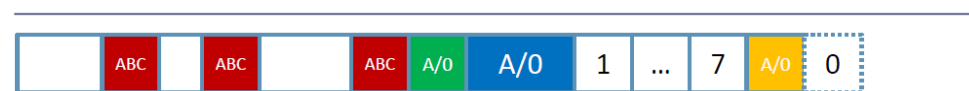
3 nodes (A, B, C) eligible to take the coordinator role, plcaNodeCount = 8 (default)



Ex 1: simple case, node A sends the BEACON first, nodes B and C “hear” it and renounce



Ex 2: BEACONS from A and B collide, then A and B hear the BEACON from C and both renounce.



Ex. 3: worst case, BEACONS from A, B, C collide repeatedly then nodes B and C detect the COMMIT from A and renounce. If the packet from A collided, then **the MAC** would re-transmit after the usual random back-off



NOTE that during this time nodes can still send/receive data in plain CSMA/CD mode

Changes to Existing PLCA State diagrams

PLCA Control & PLCA Data

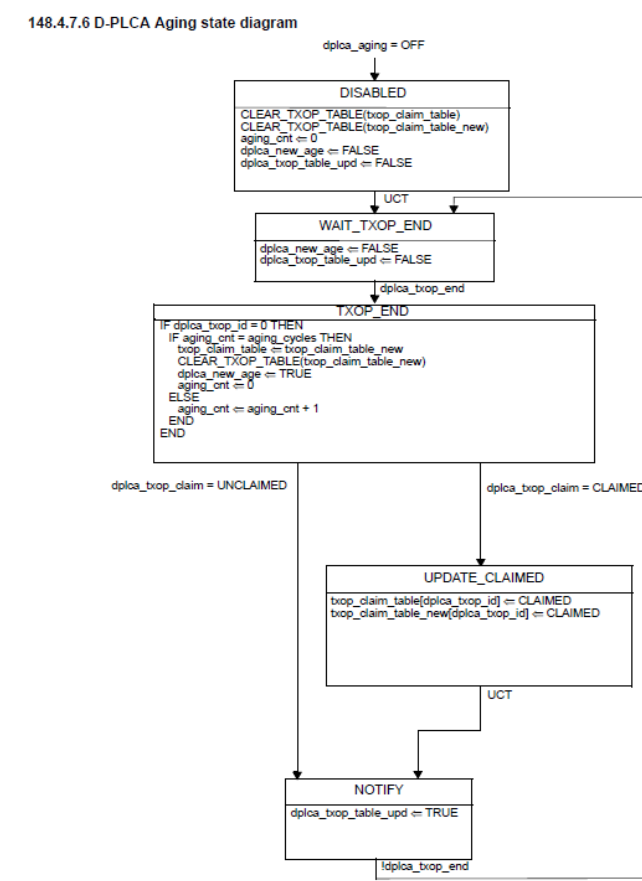
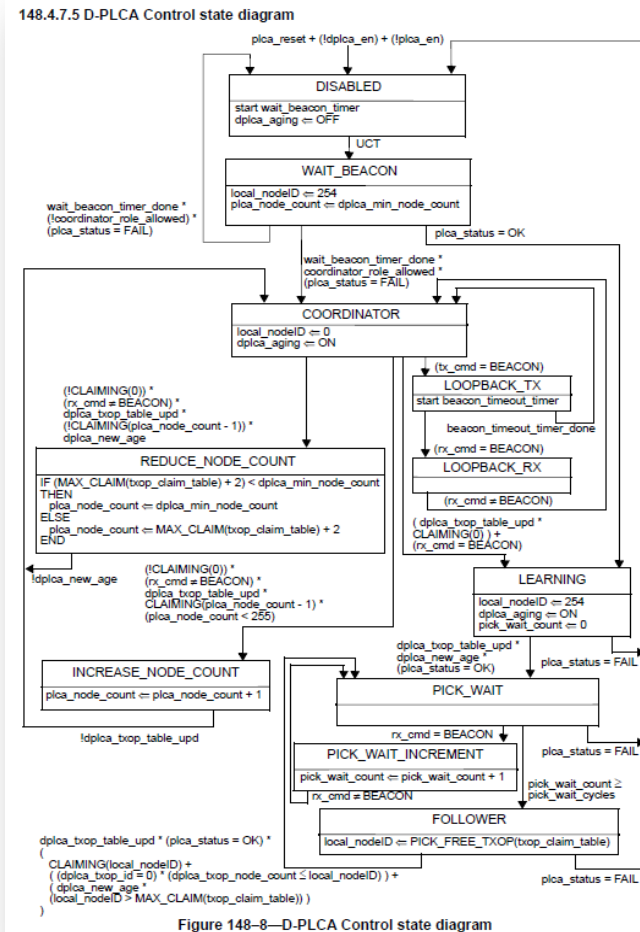


PLCA Control state diagrams (Figures 148-3 and 148-4):

- Incorporate D-PLCA initialization
- Synchronize with D-PLCA TxOp Claim Table updates and aging when D-PLCA is enabled

PLCA Data state diagrams (Figures 148-5 and 148-6) fix corner cases found since initial publication:

- Prevent errors when switching from CSMA/CD to PLCA (waiting for CRS to drop on exiting NORMAL)
- Prevent errors at the end of a burst (removing synchronization out of WAIT_IDLE when committed)
- Abort on error (plca_txer) from COLLIDE state (frame aborted from upper layer)
- For more information, see, e.g., PLCA Corner Case fixes, P. Beruto,
https://www.ieee802.org/3/da/public/022322/beruto_3da_01_230222_plca_fixes.pdf



New State diagram functions in a nutshell

D-PLCA Control

- Only functions when dplca (and plca) are enabled
- Assigns coordinator, if coordinator role is allowed for a node
- Transmit opportunity `plca_node_count-1` is always unused, allowing new claims
- Adjusts PLCA node count based on claims (with a settable minimum)
- Assigns node's transmit opportunities based on offered and observed traffic

D-PLCA Aging

- Only operates when aging is enabled
- Updates Transmit opportunity table by periodically clearing out table and refilling as nodes transmit (aging period is settable)
- Follower nodes monitor transmit opportunities to resolve conflicts, selecting new opportunities as needed

Summary

IEEE 802.3da Multidrop Enhancements: Review

Enhancements support plug-and-play multidrop with 10BASE-T1S

- Half duplex operation, 10 Mb/s, shared media PHYs, backward compatible with Clause 147 10BASE-T1S
- ***SAME PCS & PMA, SAME Registers, SAME PHY as 10BASE-T1S...., but only multidrop mode***

Refined specifications on PHY electricals, Mixing Segment & Interface to improve multidrop plug & play experience

- Improving specifications of the mixing segment and interface (TCI) to better support plug-and-play operation, longer reach, and more nodes

Adds dynamic assignment of PLCA Node IDs and coordinator (D-PLCA)

Adds a “Cold Power” powering protocol for multidrop busses

Thank You!
