New Specification of Current 802 LLC

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Re: 802.1 Maintenance, related to IEEE Std 802-2014, IEEE Std 802.1AC-2016, and IEEE Std 802.1Q-2018
Venue:
802.1 Maintenance TG

Abstract
This document proposes a detailed description of LLC, as commonly implemented in 802, to replace 802.2. It supports only the protocol multiplexing function of 802.2 and also supports protocol multiplexing based on Ethertype, providing a detailed specification of LPD and EPD and including the architectural role of VLAN tagging. The results are not intended to provide any novel protocols but instead simply to specify architecture and terminology in accordance with current usage. This contribution is a followup to maint-Marks-hlpde-0919-redacted.pdf, maint-Marks-epd-lpd-0719-v02, and maint-Marks-hlpde-spec-0420-copyright-v01.

Note:
This document represents the current views of the author only and is offered as a basis for discussion. More development is needed.

The author appreciates valuable contributions and comments from Norm Finn and Mick Seaman.

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New Specification of Current 802 LLC

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2020-05-21
IEEE 802.1 Maintenance TG

Summary

- A prior contribution <maint-Marks-hlpde-0919-redacted.pdf> said:
  - *The de facto LLC is the HLPDE. The root of the problem is that the HLPDE is not specified. It should possible to specify the HLPDE for clarification, without altering current understanding of the expected operation.*
- maint-Marks-hlpde-spec-0420-copyright-v01 proposed to specify HLPDE so that HLPDE and 802.2 comprise the LLC.
- Contributors have noted defects with 802.2 and the obsolescence of the standard; however, 802.2 cannot be maintained since the standard was withdrawn.
- Instead of specifying specify HLPDE, this contribution proposes to delete the reference to 802.2 and instead provide a specification of the LLC, as currently understood in 802, that incorporates only the protocol multiplexing function of 802.2 and also supports protocol multiplexing based on Ethertype, including a detailed specification of LPD and EPD.
- The results are not intended to provide a novel protocol but instead simply to specify architecture and terminology in accordance with current usage.
- Bridging architecture is not proposed for specification in IEEE Std 802.

IEEE 802 LLC

- LLC is a core concept in IEEE 802
  - Per IEEE Std 802, DLC has two sublayers: LLC and MAC
  - LLC is the client of the MAC service

- LLC is not specified in IEEE Std 802
  - it vaguely discusses a “higher layer protocol discrimination entity”
  - examples show components of MAC frames without naming their origins
  - frame examples are complicated because they aggregate all layers

- IEEE Std 802 has one mention of IEEE Std 802.2 (“Logical link control”):
  - *IEEE Std 802.2™-1989 (reaffirmed 2003) was administratively withdrawn as an IEEE standard on 11 January 2011 in deference to the stabilized standard ISO/IEC 8802-2:1998 where the same material continues to be available.*

- Many (most) aspects of 802.2 are not currently implemented.
- A withdrawn standard cannot be revised or amended.

MAC Expectations of LPDU

- The 802 MAC standards specify expectations of the LPDU format
- 802.3: "The services provided by the MAC sublayer allow the local MAC client entity to exchange LLC data units with peer LLC sublayer entities."
  - LLC data unit (MSDU) is not an opaque packet; it is presumed to have structure known to the MAC [a bit of a layer violation] starting with a Length/Type field.
  - *The MAC service per IEEE 802.3 (normative subclause 4A.3.2) specifies:*
    - *lengthOrType: The value of the first two octets at the start of the mac_service_data_unit*
    - *data: The value of mac_service_data_unit excluding the first two octets*
    - This LDPU format is not specified in any 802 LLC standard.
- 802.11 expects a particular LLC format that is not documented in IEEE Std 802:
  - *Logical Link Control (LLC) sublayer entities use the MAC sublayer service to exchange PDUs with peer LLC sublayer entities. These PDUs are termed MAC sublayer SDUs (MSDUs) when sent to the MAC sublayer.*
  - *There are two LLC sublayer protocols used (see IEEE Std 802); LLC Protocol Discrimination (LPD) (see ISO/IEC 8802-2:1998) and Ethertype Protocol Discrimination (EPD) (see IEEE Std 802.3-2012).*
  - *MSDU format parameter indicates if the received MSDU is in EPD or LPD format.*
  - EPD format is not specified in any 802 LLC standard.
  - 802.11 has no normative specification of the Length/Type field
    - e.g. when it's a length and when it's a type
    - What if an 802.11 length is later interpreted as an 802.3 type?
- ➢ We need an LLC specification, common to all MACs, to specify the LPDU format(s)

802.2 Functionality

- 802.2 supports three LLC types
  - Type 1: connectionless and unacknowledged
  - Type 2: connection-oriented
  - Type 3: connectionless but acknowledged
- This LLC specification supports only Type 1 multiplexing function
  - does not support Type 2 or 3
- 802.2 supports four “classes” of LLC operation
- This LLC specification supports only Class I
  - Class I is “data-link connectionless-mode”
- Per the 802.2 Type 1 description:
  - *There exists for each MAC service access point one and only one LLC entity, consisting of the various operating components.*
  - *In Class I LLC operation, each LLC can have zero or more SAPs being serviced (i.e., active) at any one time, independent of each other, which are differentiated by the DSAP address.*

HLPDE per IEEE Std 802-2014

The LLC sublayer contains a variety of entities, as illustrated in Figure 6.

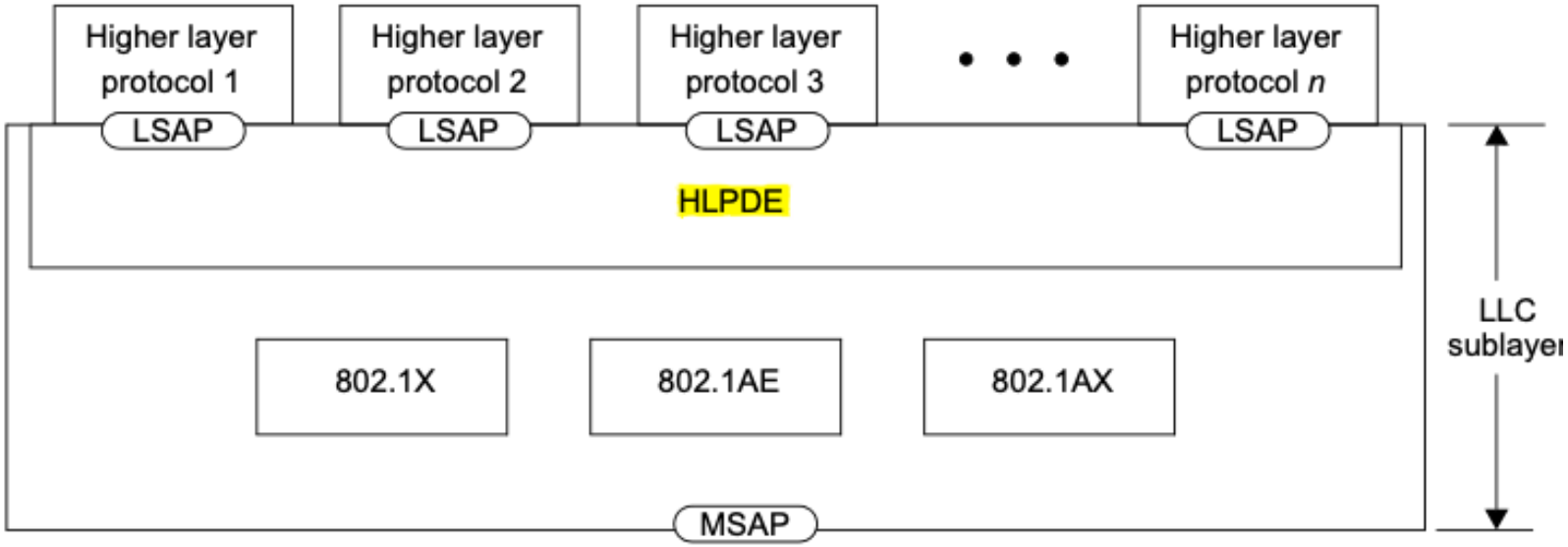

Figure 6—LLC sublayer in 802 RM

IEEE Std 802-2014:
The higher layer protocol discrimination entity (HLPDE) is used by the LLC sublayer to determine the higher layer protocol to which to deliver an LLC sublayer protocol data unit (PDU). Two methods may be used in the HLPDE. The two methods are:

1) EtherType protocol discrimination (EPD), which uses the EtherType value made available to the LLC sublayer through the MSAP
2) LLC protocol discrimination (LPD), which uses the addresses defined in ISO/IEC 8802-2, including the Subnetwork Access Protocol (SNAP) format

- As discussed in prior contributions, the descriptions of EPD and LPD in IEEE Std 802-2014, 802.1AC, and 802.1Q are inconsistent.
- Since EPD and LPD are HLDPE methods, this contribution seeks to resolve the issues by developing a detailed specification of the LLC incorporating higher layer protocol discrimination.

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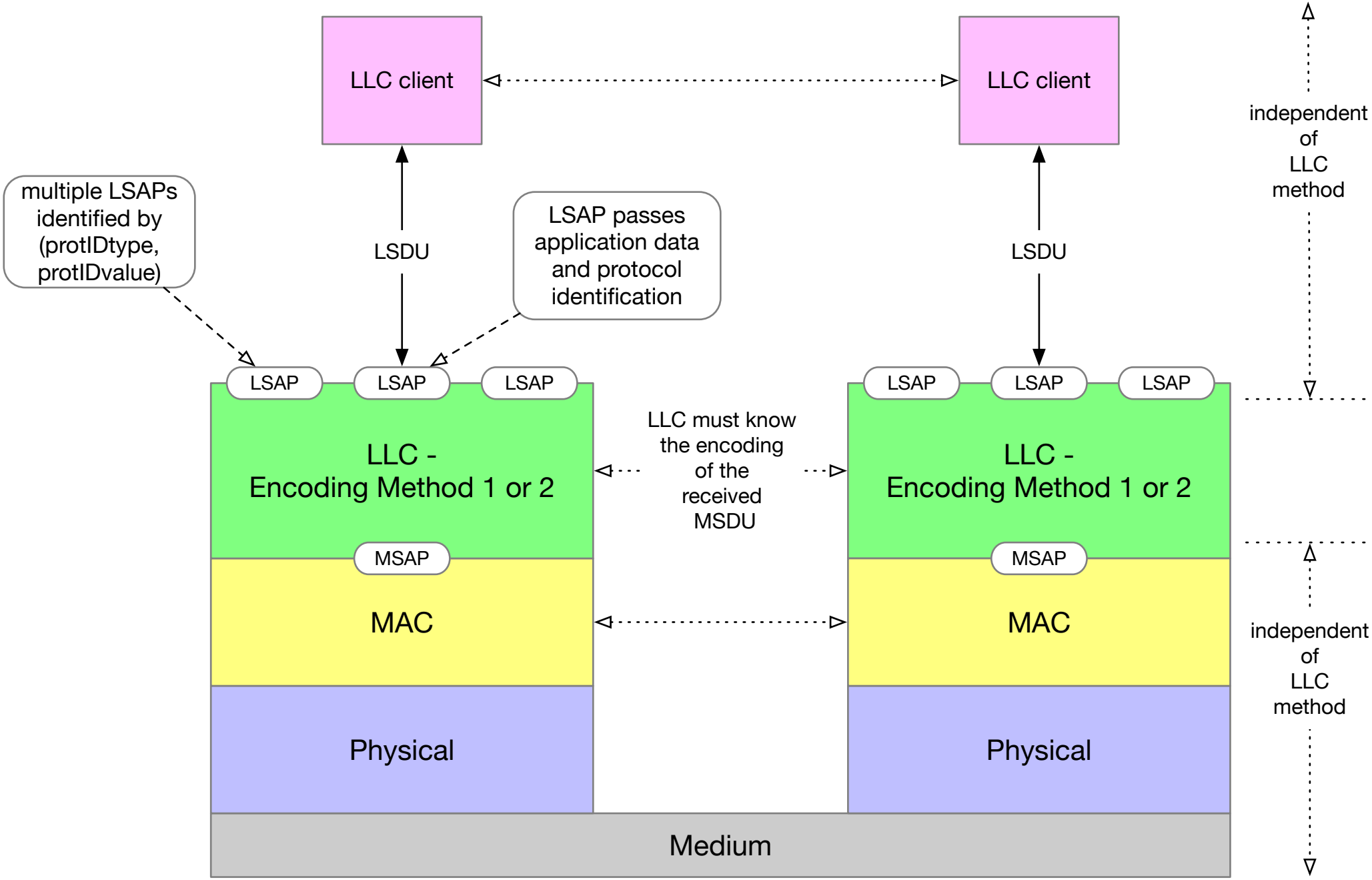
New LLC Spec in the 802 Architecture

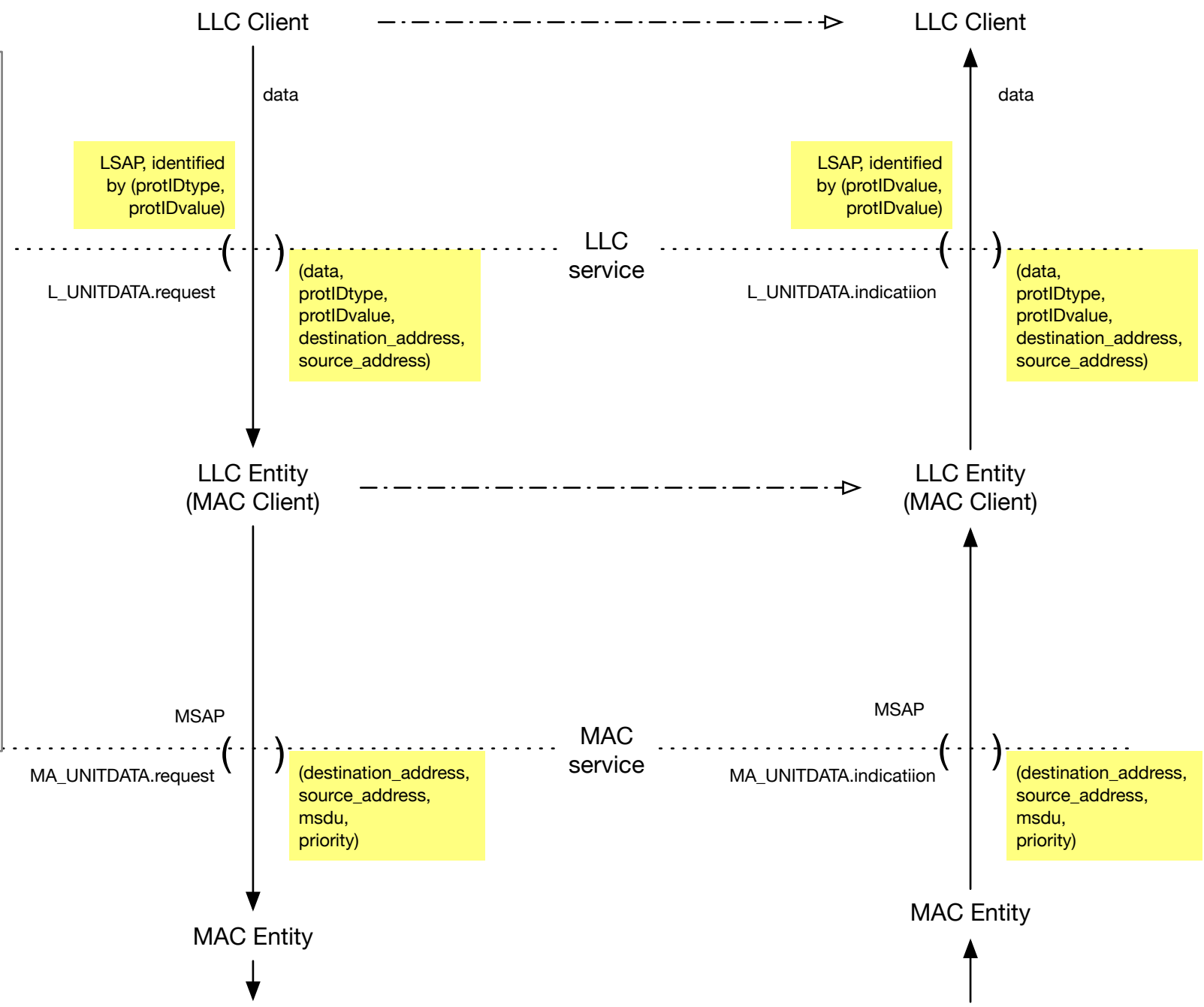


LSAP Service Primitives in New LLC Spec

Analogous 802.2 primitive is DL-UNITDATA request (source_address, destination_address, data, priority)

Per 802.2:
The "source_address" and "destination_address" parameters provide at a minimum the logical concatenation of the MAC address field (SA and/or DA) and the LLC address field (SSAP and/or DSAP).

That is, it's not the job of the LLC to determine the MAC DA and SA; that needs to be passed down from LLC Client.

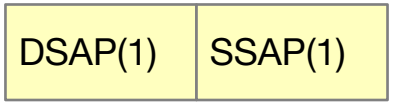
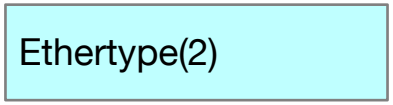


LLC Operation

- LSAP is identified by (protIDtype, protIDvalue)
- LSAP passes (data, protIDtype, protIDvalue), plus MAC DA/SA
- LLC encodes (data, protIDtype, protIDvalue) into the MSDU
- LLC sends MSDU to MSAP, along with MAC DA/SA
- Peer LLC, from MSAP, receives MSDU with MAC DA/SA
- From MSDU, LLC determines (data, protIDtype, protIDvalue)
    - then forwards data (& MAC DA/SA) to LSAP identified by (protIDtype, protIDvalue)

protIDtypes and protIDvalue formats

The protocol is identified at the LSAP using:
(a) protIDtype (either “L”, “E”, or “O”)
(b) protIDvalue, using a specific format for each protIDtype:

protIDtype	**protocol identifier format (PIF)**	
L	LSAP	
E	EtherType	
O	OUI Extended	

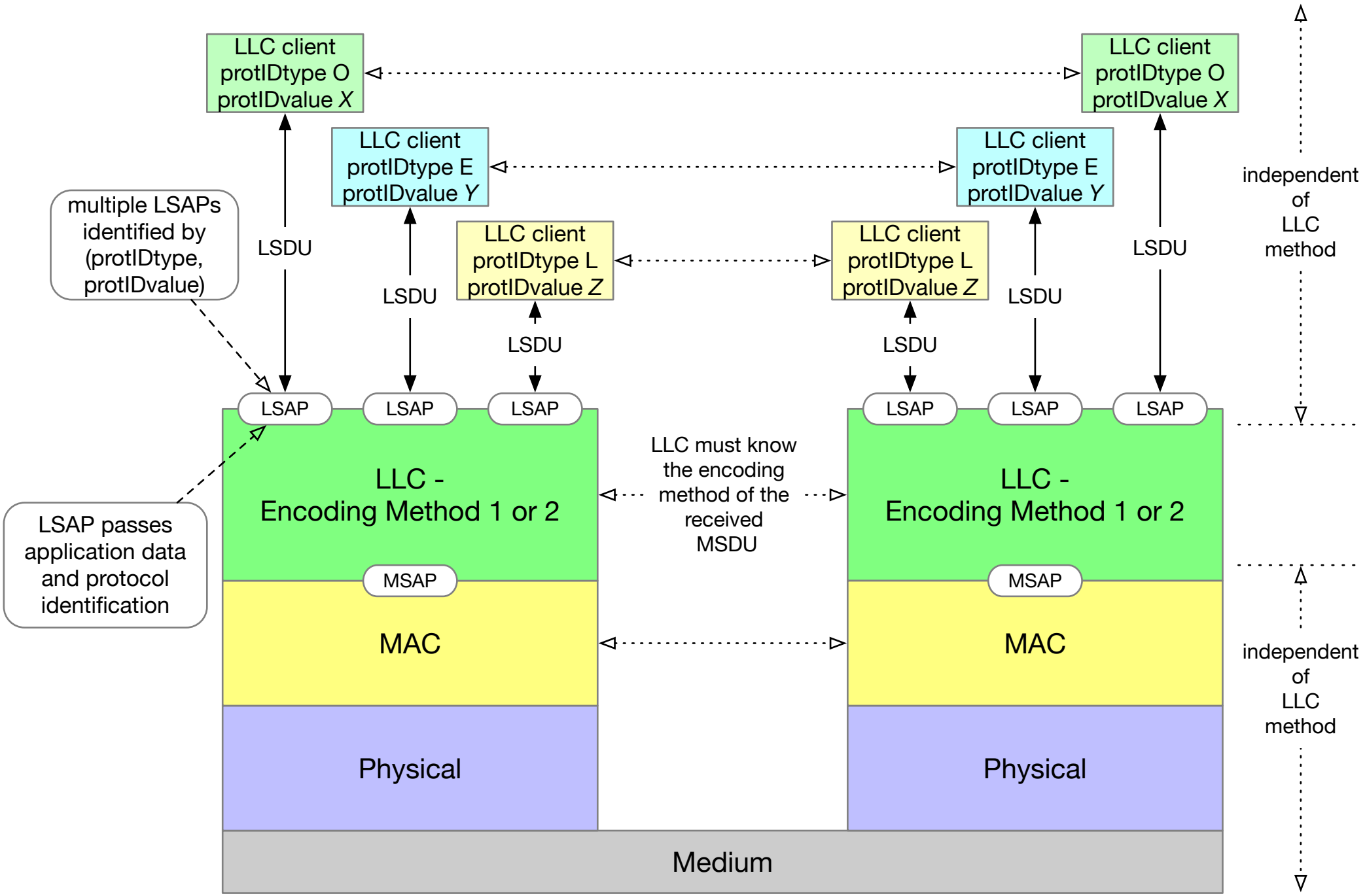
Note 1: LSAP identifier is a compound identifier consisting of DSAP (destination identifier) and SSAP (source identifier). Packet is delivered to LSAP identified by DSAP.

Note 2: If DSAP is a group identifier, packet may be delivered to more than one LSAP within the end station (but this behavior could be deprecated, considering that it has been marked “for further study” for over 25 years.)

Note 3: The OUI/CID Extended identifier is specified in IEEE Std 802 to begin with a registered OUI, OUI-36, or CID, with additional bits specified by the assignee of that registered identifier to uniquely identify the protocol.
For LLC purposes, the structure of the O Identifier is irrelevant, but it may not begin with 00-00-00.

Note 4: if protIDtype = E, protIDvalue is $>1535_{10}$ and not equal to 88-B7 or C9-D1.

LLC Clients match by (protIDtype, protIDvalue)



LLC Encoding Methods

•Two LLC Encoding Methods are supported:
  -Method 1: EPD (Length/Type)
  -Method 2: LPD (LSAP/SNAP)

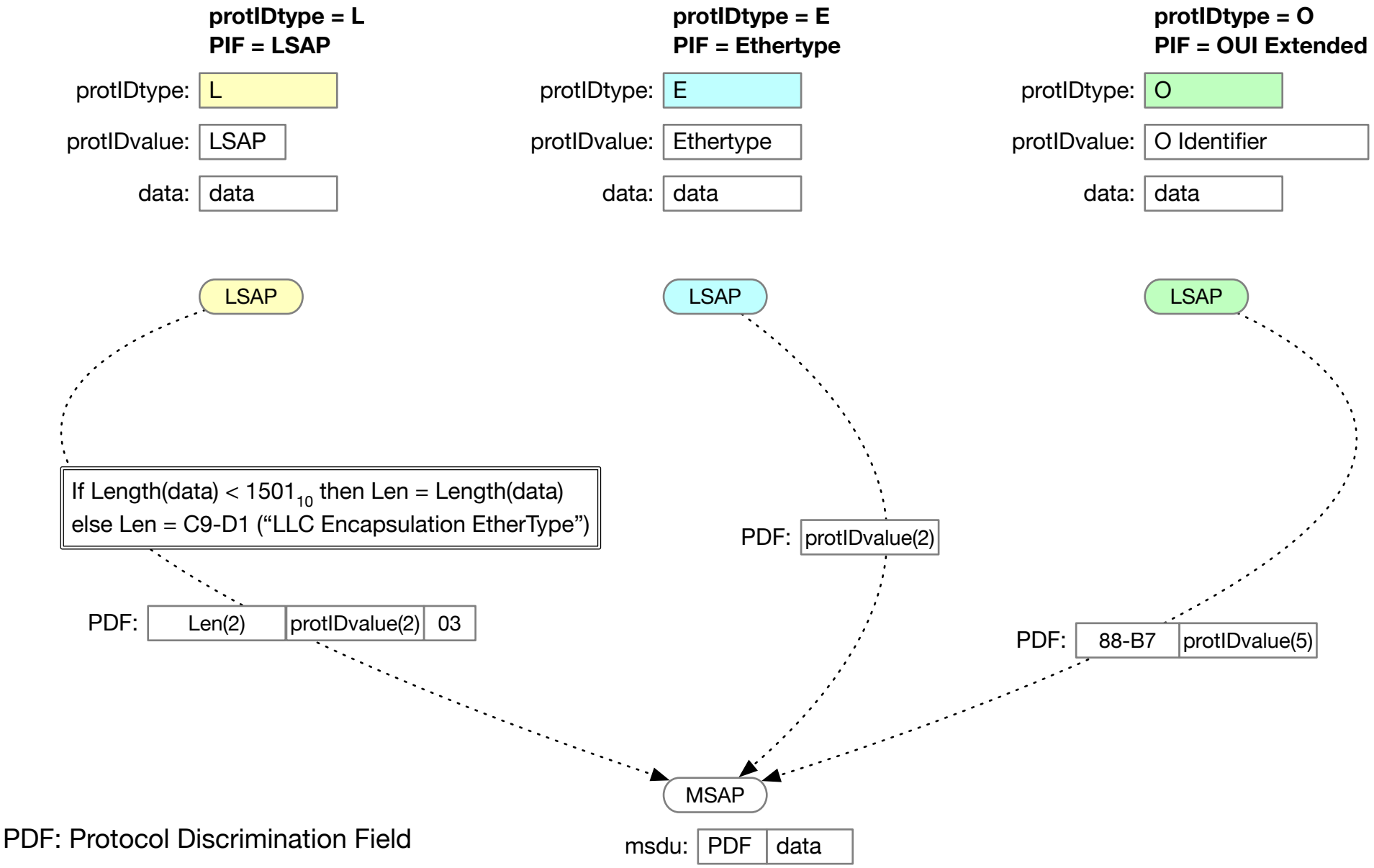
•The two Methods are different and incompatible, so the receiver LLC must know the LLC encoding of the received frame in order to be able to decode it.

•Both Methods support all three protIDtypes.

•The client (LSAP and up) and the MAC (MSAP and down) are Method-independent
  -note: therefore there is, in general, no “EPD MAC” or “EPD medium” (nor LPD)
  -however, a MAC specification may specify which method it presumes used or how the method may be identified at a station

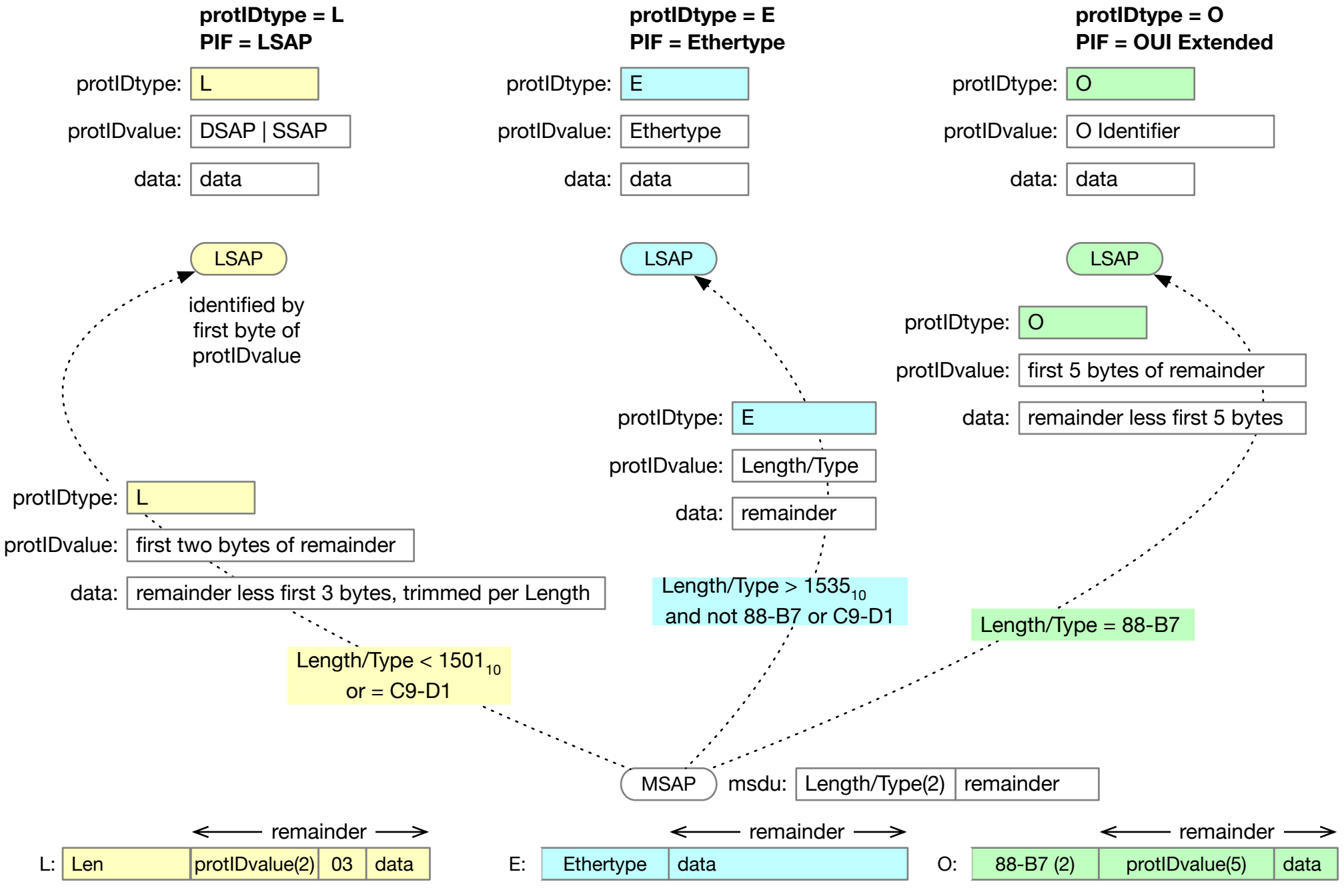
encoding formats	**protIDtype: L**	**protIDtype: E**	**protIDtype: O**
Method 1: Length/Type (EPD)	Length	Type	Type
Method 2: LLC/SNAP (LPD)	LSAP	SNAP	SNAP

LLC Method 1 (EPD) Encoding

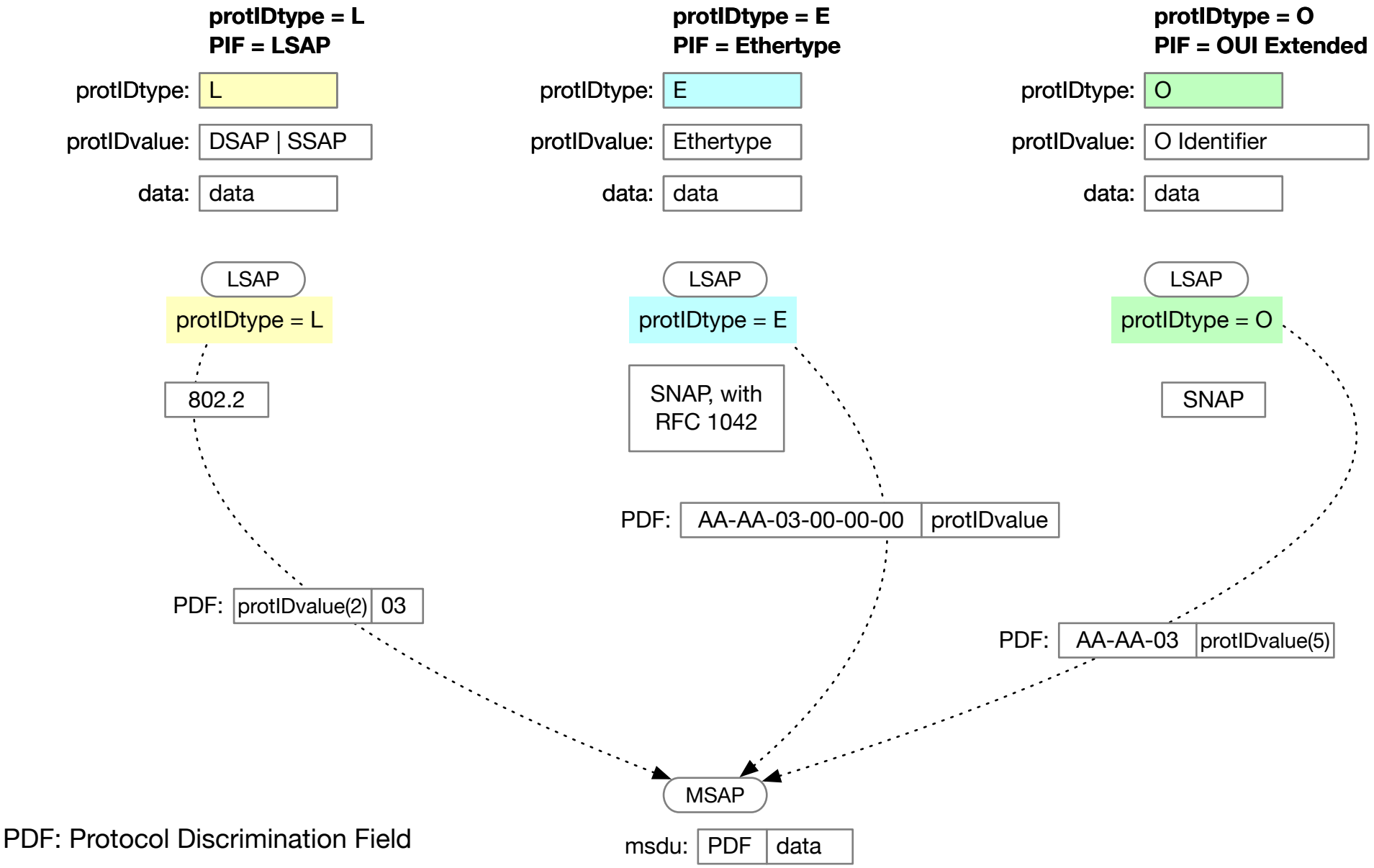


PDF: Protocol Discrimination Field

LLC Method 1 (EPD) Decoding

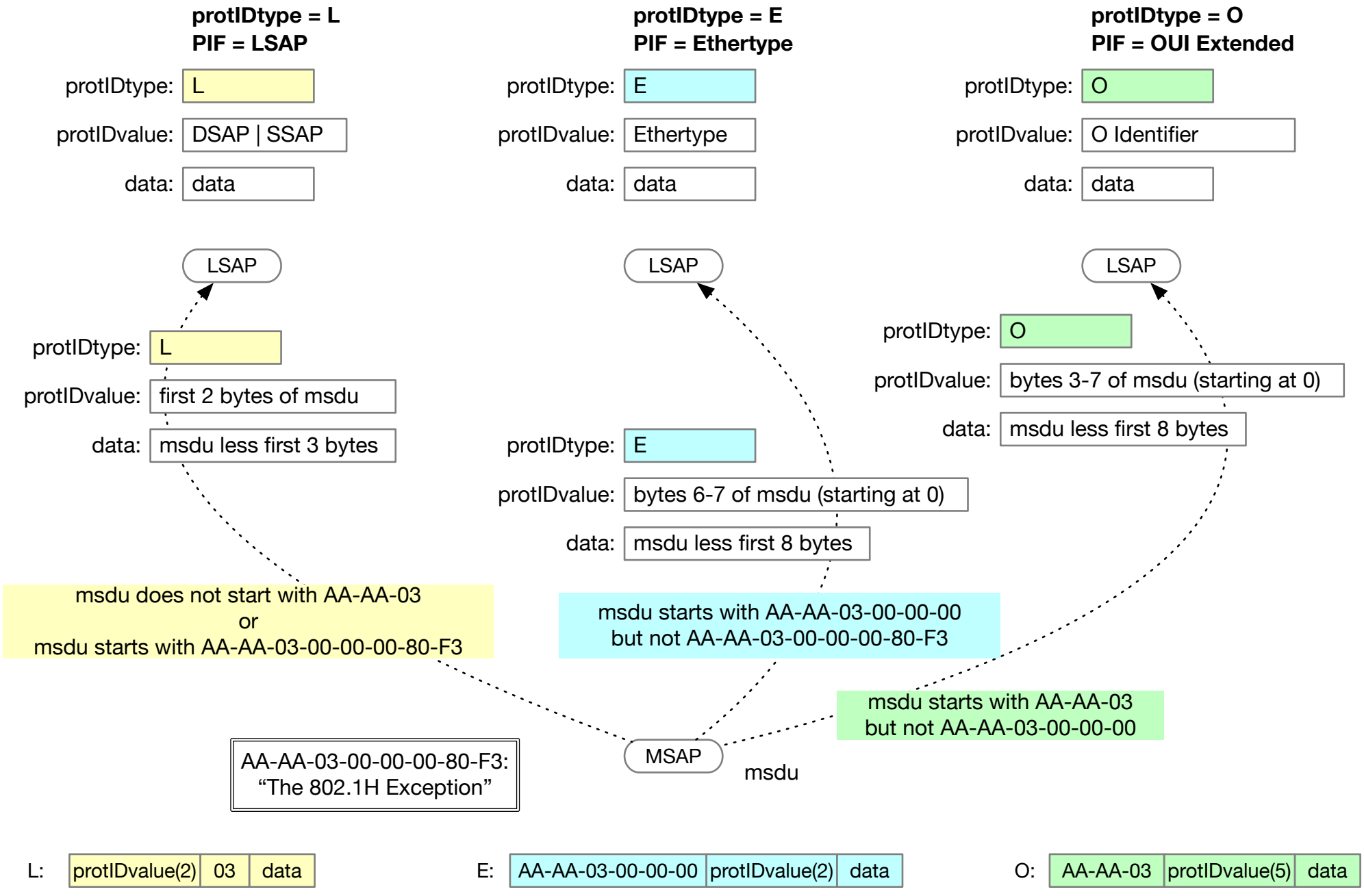


LLC Method 2 (LPD) Encoding



PDF: Protocol Discrimination Field

LLC Method 2 (LPD) Decoding



SNAP Shims for specific LSAP Frame Formats

The described architecture is sufficient to handle any protocol using any of the three protIDtypes.

The LSAP primitive specifies parameters to be passed, but not specified frame formats used to pass the data.

Various forms of protocol identification have been introduced over the years, sometimes based on specific frame formats at the LSAP.

Here two SNAP shims are introduced:

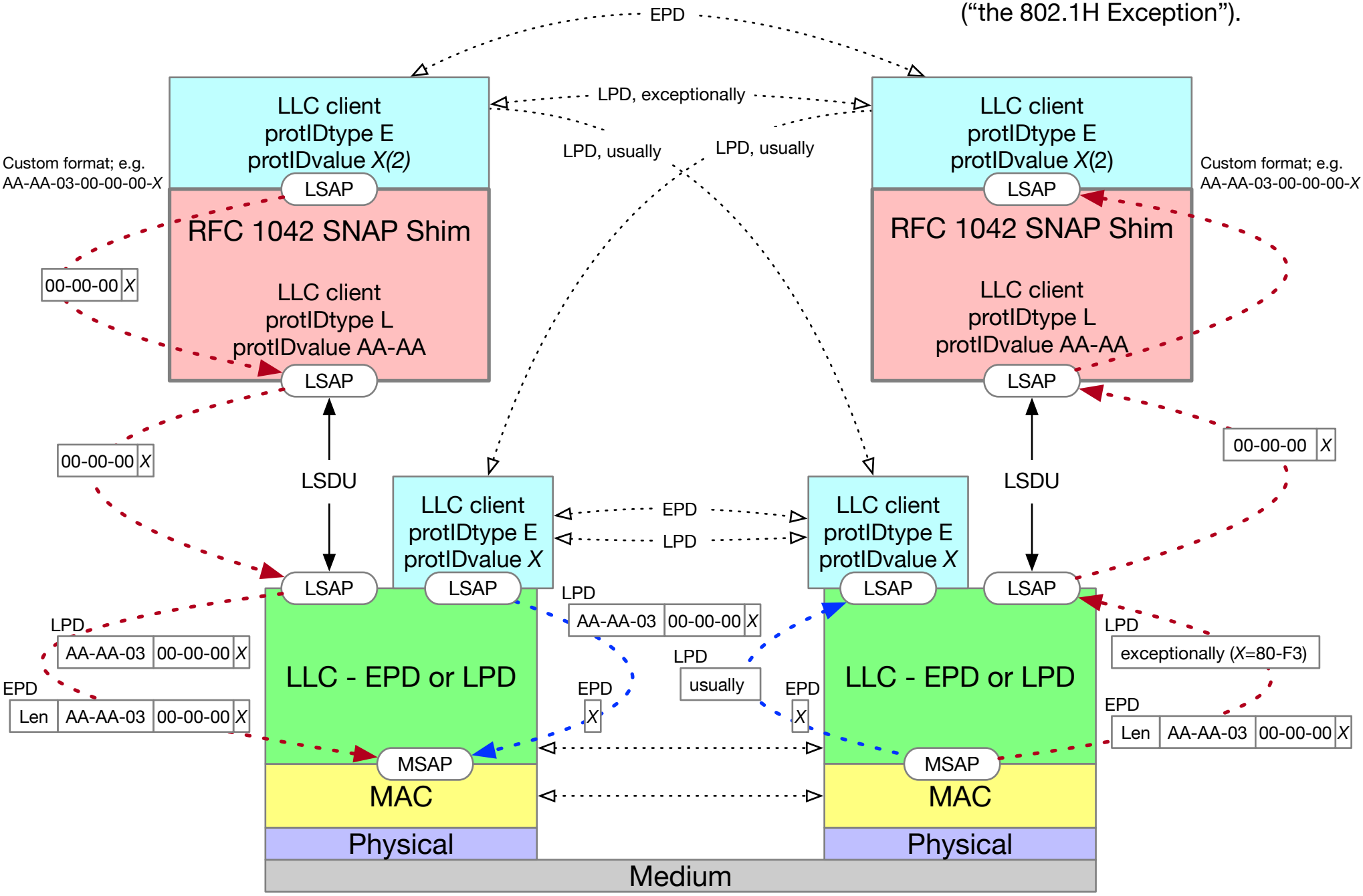
- The RFC 1042 SNAP shim provides a second way to support protIDtype E LLC clients.
- The O-SNAP shim provides a second way to support protIDtype O LLC clients.

In each case, the frame format at the SNAP shim LSAP is specified.

RFC 1042 SNAP

EPD forwards to different LSAPs, though protIDvalue = *X* in both.

LPD forwards to protIDtype=E LSAP, unless the Ethertype is on a list, including only 0x80F3 (“the 802.1H Exception”).



RFC 1042 SNAP Shim Functionality

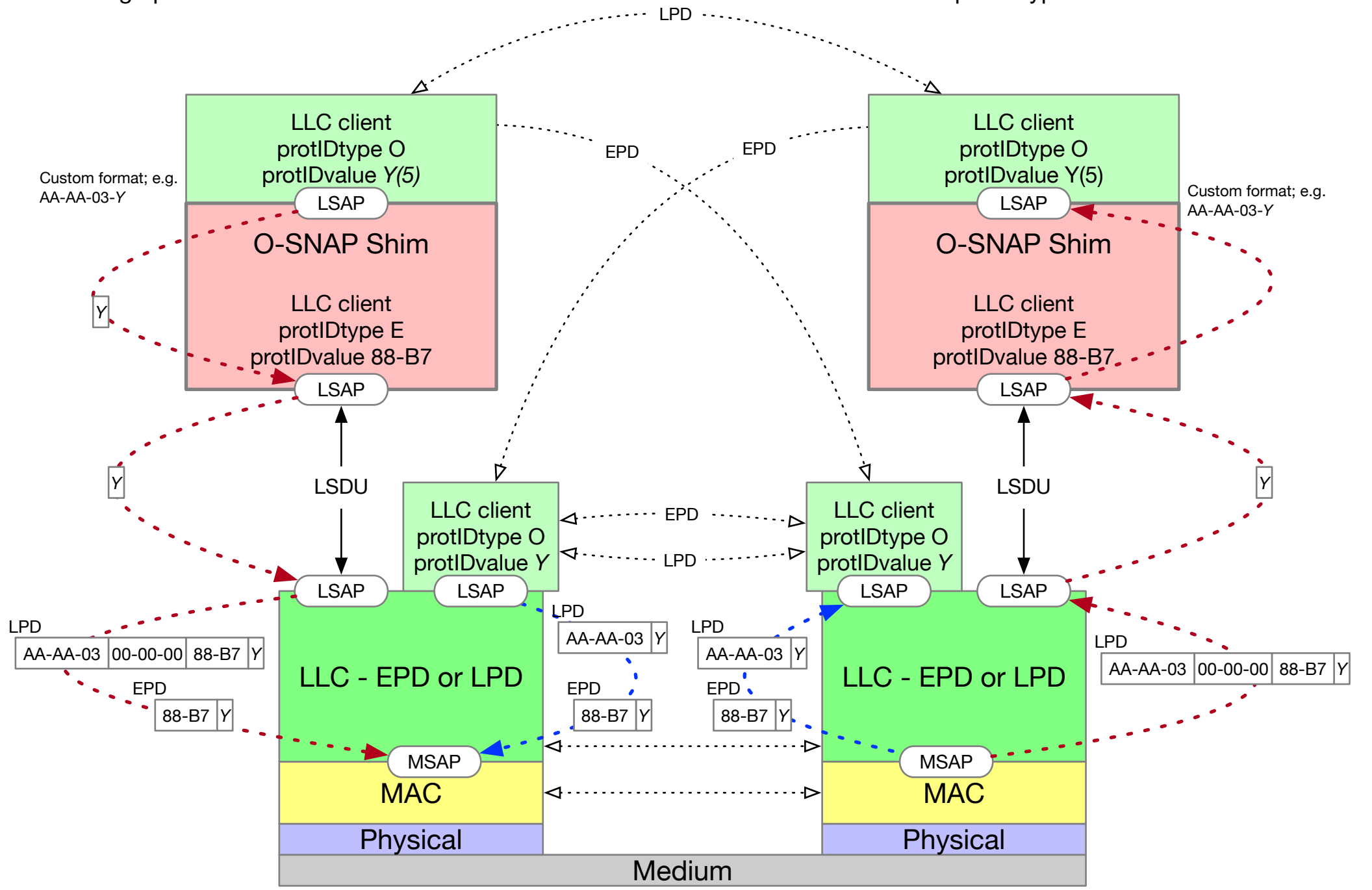
- Going down:
  - -if protIDtype = E
    - -determine X = protIDvalue
    - -prepend 00-00-00-X to data
    - -send data to LSAP with protIDtype = L and protIDvalue = AA-AA
  - -else reject frame

- Going up:
  - -determine X as bytes 3-4 of data (starting with 0)
  - -prepend AA-AA-03 to data
  - -deliver data the LSAP identified by X

O-SNAP

LPD forwards to different LSAPs, though protIDvalue = *Y* in both.

EPD forwards both frames to protIDtype=O LSAP.



O-SNAP Shim Functionality

- Going down:
  - -if protIDtype = O
    - -determine Y = protIDvalue
    - -send data to LSAP with protIDtype = E and protIDvalue = 88-B7
  - -else reject frame

- Going up:
  - -determine Y as bytes 0-4 of data (starting with 0)
  - -prepend AA-AA-03 to data
  - -deliver data the LSAP identified by Y

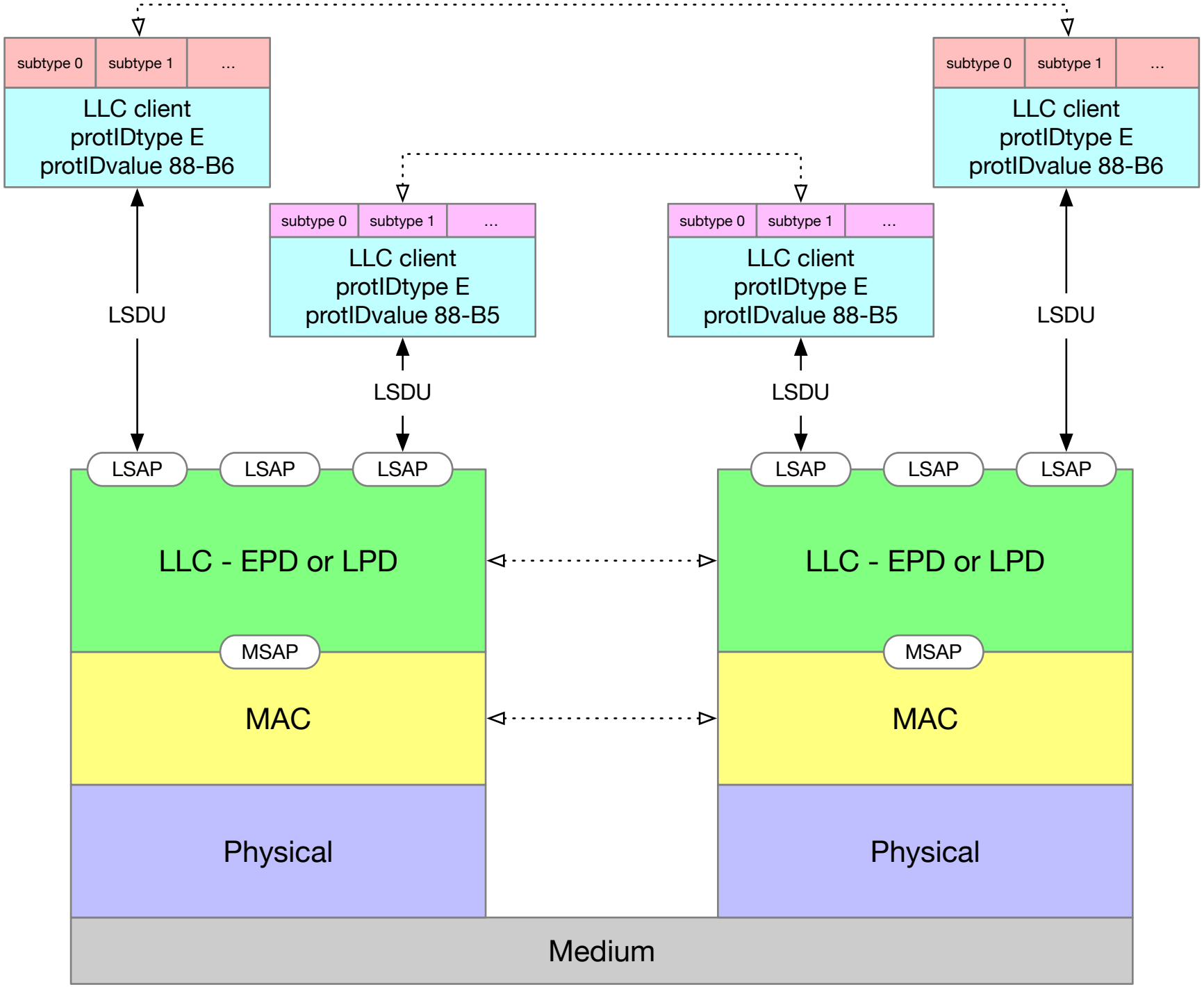
Playpen EtherType

Local Experimental EtherType (Playpen EtherType):

- Introduced in IEEE Std 802a-2003 (“Ethertypes for prototype and vendor-specific protocol development”)
- specified in IEEE Std 802 with a subtype and version, of unspecified length, that are locally interpreted, not resolved in the LLC
- LLC directs the frame to the LSAP identified by 88-B5 or 88-B6
- The locally-specified application at that LSAP is responsible to take any appropriate actions corresponding to the local protocol subtype and protocol version fields.
- This is fully consistent with the proposed LLC architecture, without modification.

Local Experimental EtherType 1:	88-B5	protocol subtype	protocol version	data
Local Experimental EtherType 2:	88-B6	protocol subtype	protocol version	data

Playpen Ethertype



MSDU Content and Format in the MAC

- The MSDU is created by LLC, with a structure and format directed to be read by LLC.

- In principle, MAC sees MSDU as a data unit without structure or format.
  - in accordance with good layering principles

- For example, IEEE Std 802.1AC says:
  - "*the MAC Service provides for the transparent transfer of MAC Service user data. It does not restrict the content, format, or coding of the information, nor does it ever need to interpret its structure or meaning*."

- Therefore, the choice of LLC Encoding Method (EPD or LPD) should be MAC-independent.

- In practice, this is mostly true, but not entirely accurate.

- Let's take a closer look at 802.3.

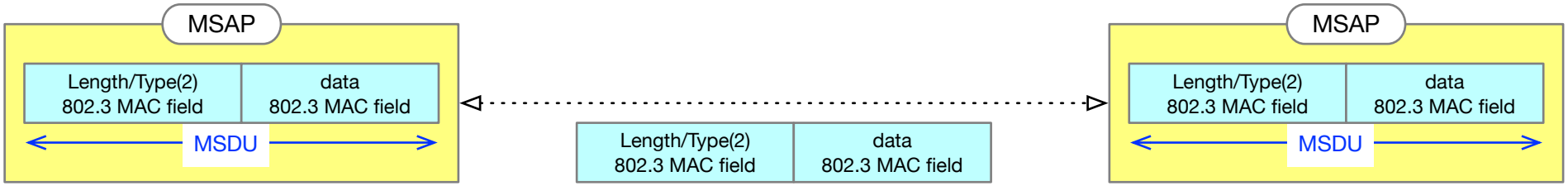
MSDU Content in the 802.3 MAC

The MAC service per IEEE 802.3 (normative subclause 4A.3.2) specifies:

-mac_service_data_unit：concatenation of the lengthOrType field and the data field parsed from the client request

-lengthOrType：The value of the first two octets at the start of the mac_service_data_unit

-data: The value of mac_service_data_unit excluding the first two octets (Length/Type field)



•Upon receipt from LLC, the MSDU is split into two MAC fields: (a) Length/Type; (b) data

•Before delivery to LLC, Length/Type and data fields are re-concatenated to form MSDU

-(these should be called out as two parameters passed over the MSAP; oh well)

•When the Length/Type is interpreted as a Type, it is not used by the 802.3 MAC, and the MSDU is delivered as received, so the structure and content of the MSDU are irrelevant.

•However, when the Length/Type is interpreted as a Length, it is used by the 802.3 MAC to remove the pad field [note: unless passReceiveFCSMode variable is set on]

-802.3: “Length checking is provided for Length interpretations of the Length/Type field.”

-Otherwise, 802.3 takes no action in response to the Length/Type field.

•What if an LPD MSDU was sent to 802.3?

-If the first byte was $>1535_{10}$, it would be transferred without problem.

-If the first byte was $>1500_{10}$ and $<1536_{10}$, it could be rejected.

-If the first byte was $<1501_{10}$, then frame could be trashed (trimmed or dropped).

Theoretical: sending an LPD MSDU over Ethernet

•An LPD MSDU always begins with DSAP/SSAP
  -e.g. this may be “AA-AA”
    -AA-AA = 43960_{10} => Type interpretation
    -this may match an Ethertype, but the 802.3 MAC doesn’t care; no problems arise

DSAP	SSAP	decimal value	Length/Type	DSAP Assignment*
00	00	0	Length	null address
00	01-FF	1-255	Length	none
01	00-FF	256-511	Length	none
02	00-FF	512-767	Length	802.1B (withdrawn)
03	00-FF	768-1023	Length	none
04	00-FF	1024-1279	Length	none
05	00-DC	1280-1500	Length	none
05	DE-FF	1501-1535	invalid	none
06	00-FF	1536-1791	Type	
07	00-FF	1792-2047	Type	
>07	00-FF	…	Type	
FF	FF	65535	Type	

•An LPD MSDU can begin with two octets that look to Ethernet like a length or an invalid Type/Length field

•This happens only with *DSAP=00, 01, 02, 03, 04, 05

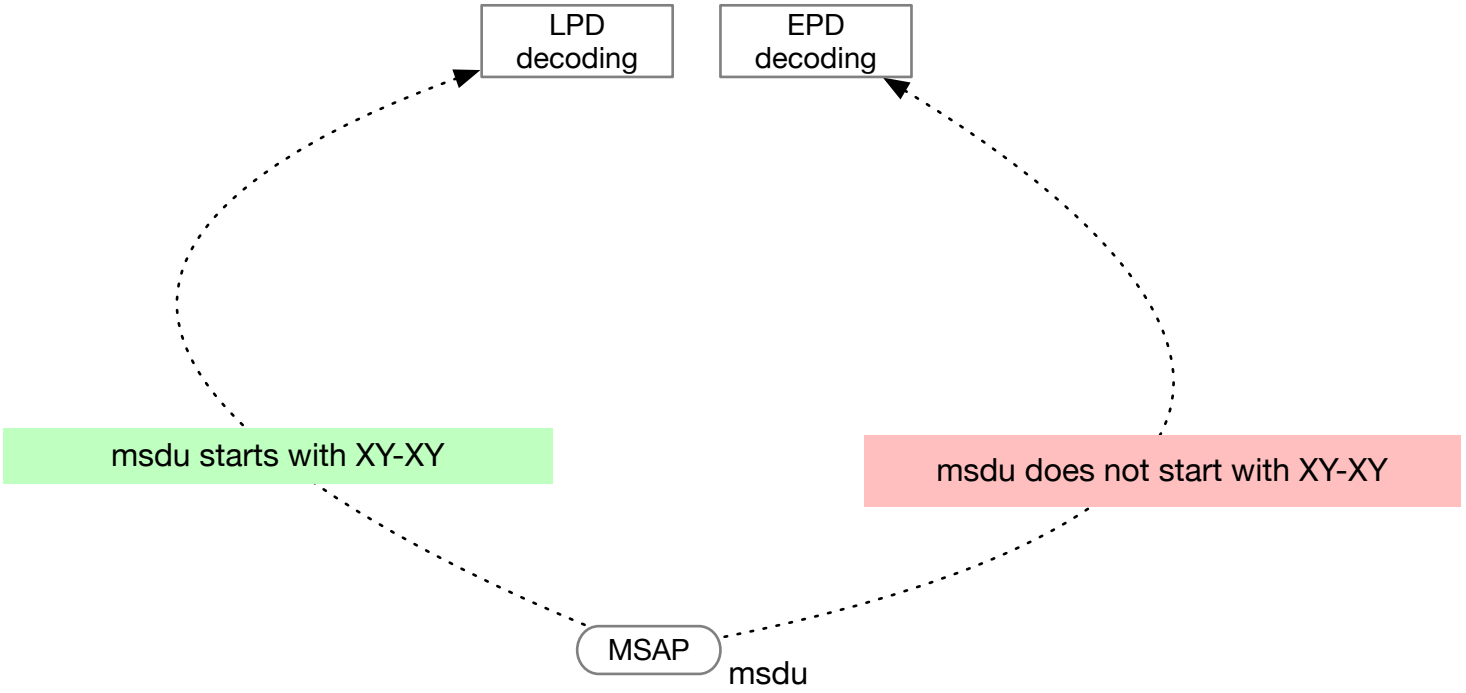
•But those DSAP values are not assigned to protocols.

•LPD works fine over Ethernet for any valid DSAP/SSAP value.

*Possible exception if DSAP=00. Per 802.2, that null address represents the MSAP and may not be used as an address of an LSAP.

* https://standards.ieee.org/products-services/regauth/llc/public.html

LLC Universal Decoding?



The approach above doesn't quite work:

•On one hand:
- -as shown, DSAP/SSAP does not overlap Length values
- -there seem to be about 17 assigned Ethertypes of the form XY-XY
  - -none overlaps an existing active DSAP/SSAP assignment.

•On the other hand, about 11 of them overlap the "unreserved" LSAP range, which is available for local use.

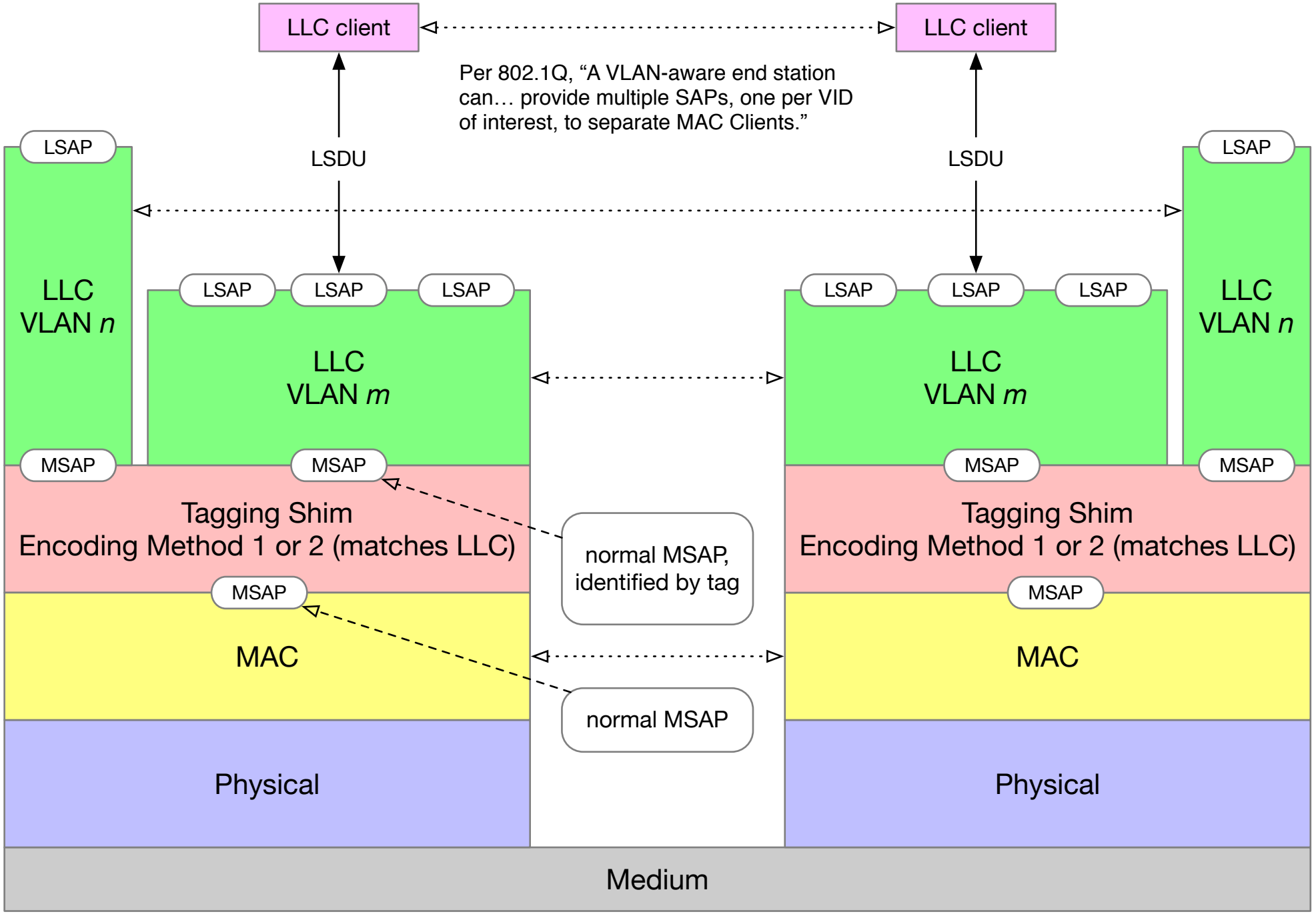
•If future Ethertype assignments continue to avoid overlap with XY-XY assignments (or if these are not supported in the implementation), and if local LSAP use of the XY-XY form is avoided, LLC Universal Decoding would be possible with this method.

•Probably not worth trying to find a standardized solution.

End-Station Tagging

- We should represent tagging in the architecture.
  - -only at the end station
  - -bridging architecture is separate and is not being proposed for IEEE Std 802

End Station Tagging Shim in the 802 Architecture



Tagging Methods

•Two Tagging Methods are supported:
  -Method 1: EPD (Length/Type): uses simple type-based tag
  -Method 2: LPD (LSAP/SNAP): uses SNAP-based tag

•Going down, the tag is added per the MSAP identifier.
•Going up, the tag is read and stripped; the data is passed to the identified MSAP.

•Per 802.1AC, the LPD method also changes the data's protocol identification encoding (added in the LLC sublayer) from LPD-like to EPD-like going down, reversing it going up.

•The two Methods are different and incompatible, so the receiver LLC must know the encoding of the received frame in order to be able to decode it.

•Both methods support all three protIDtypes.

encoding formats	**protIDtype: L**	**protIDtype: E**	**protIDtype: O**
Method 1: Length/Type (EPD)	Type	Type	Type
Method 2: LLC/SNAP (LPD)	SNAP	SNAP	SNAP

MSDU Translations

•It is possible to translate MSDU between LPD and EPD format.

•This can be useful when an MSDU encoded by an LPD LLC needs to be decoded by an EPD LLC, or vice versa.

•Such a translation could be useful, for example, in a bridge in translating a frame from a network in which EPD is presumed to one in which LPD is presumed, or vice versa.

Proposals

(1) IEEE Std 802 should be thoroughly revised, with a detailed specification of the LLC that is independent of 802.2 and includes protocol discrimination functionality based on 802.2 as well as Ethertypes

(2) EPD and LPD should be specified as LLC methods so that the rest of the architecture is independent of the LLC method

-Note: EPD and LPD per IEEE Std 802 are completely different than proposed here

(3) IEEE Std 802 should clarify the architecture and detail the roles and functions of LLC and tagging

(4) IEEE Stds 802.1AC, 802.1Q, and 802.11 should be reviewed for consistency and clarified as necessary

Conclusion

- 802 is no longer reliant on the 802.2 LLC
- There is no LLC specified in active IEEE 802 standards
- LLC should be specified within the IEEE 802 family
  - Should go into a revision of IEEE Std 802
- It should possible to specify the LLC and its current role in protocol discrimination without altering the current understanding of the expected operation.
  - Bridging architecture is not proposed for IEEE Std 802.
- This contribution proposes a view of the LLC specification.

Bibliography

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