IEEE P1905.1
Convergent Digital Home Network
Technical Presentation

802.1 Plenary Meeting

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Contributed by

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Home Networking Requirements (1/2)

- Different connectivity technologies are deployed in homes, each with its own advantages and impairments

- The Need for Convergence and Abstraction
  - **Ubiquitous Coverage**

    Combining multiple connectivity technologies improves the home coverage.

  - **Ease of installation**

    Simplified security setup unifies the specific security setup method of each technology.

Home Networking Requirements (2/2)

- **High Throughput**

  Load sharing over multiple concurrent paths amalgamates the bandwidth offered by the whole home network topology.

- **Reliability**

  Directing traffic through another path could lower transmission error rates.

  Sending some critical traffic on multiple paths and removing duplicates at the receiving end could improve reliability.

- **Management**

  Local and Remote diagnostics allow to identify network configuration issues.

P1905.1 Key Features

- Topology Discovery (to help identify bottlenecks & mis-configuration)

- Diagnostics (both locally and thru WAN accessible TR-069 data model)

- Simplified security setup (common method)

- Automatic configuration of secondary Wi-Fi Access Point(s)

- Enabler for enhanced path selection (link metrics information)

- Enabler for enhanced power management (by optimizing network power usage across different technologies)

P1905.1 is not a replacement …

… for Wi-Fi, Ethernet, MoCA, HomePlug, and other home
  network technologies

… for 802.1 bridging

… for DLNA service and content discovery

IEEE P1905.1 WG

- http://grouper.ieee.org/groups/1905/1/
- Chair: Paul Houze, Orange Labs - France Telecom
- Timeline:
  – Dec 2010   1st WG Meeting
  – Dec 2011   Draft 1.0 Approved by the WG
  – Mar 2012   Sponsor Ballot Initiation
  – Jun 2012   Sponsor Ballot Passed
  – Current Status   Sponsor Ballot Comments Resolution followed by recirculation

ARCHITECTURE

P1905.1 Abstraction Layer Model
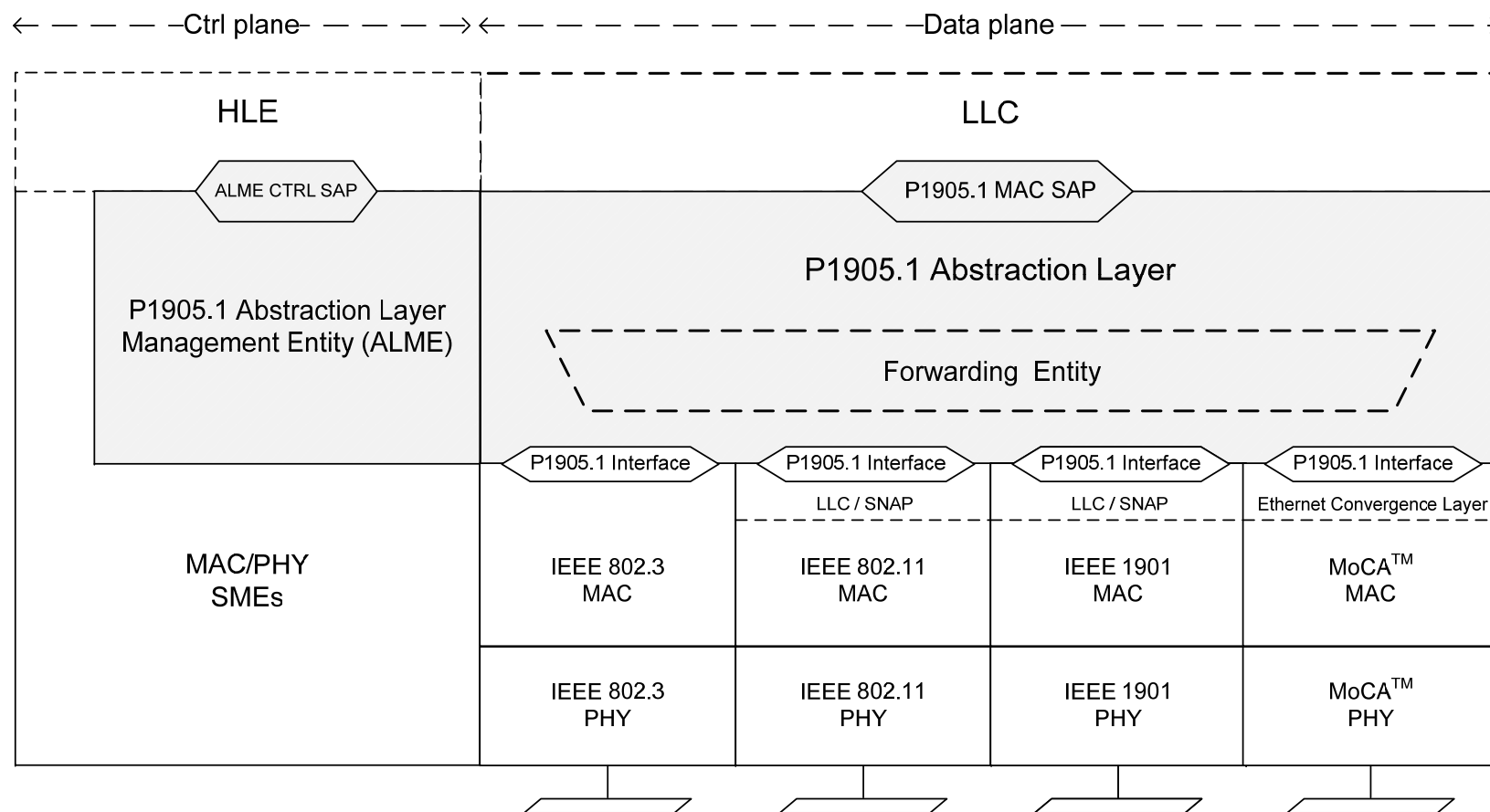
HLE = Higher Layer Entity
SME = Station Management Entity

P1905.1 Abstraction Layer

- Appears to the LLC as a single MAC
  - features a single MAC address
  - hides the heterogeneous nature of the home network...
  - ...but provides underlying link metrics to allow enhanced path selection
- Might acts as a MAC-to-MAC relay between the underlying network interfaces
  - AL ingress/egress MSDUs might be forwarded by an internal forwarding entity.
  - The behavior of this forwarding entity is not defined in this standard but if present, shall be interoperable with IEEE 802.1 bridging

- *The native bridging function of underlying MAC if any (such MoCA, IEEE 1901,...) is not modified*
- *Underlying MACs may communicate using their MAC addresses, for control purposes*

P1905.1 AL Management Plane

P1905.1 Abstraction Layer Management Entity (ALME) : management service interface for invoking layer management functions to the P1905.1 Abstraction Layer

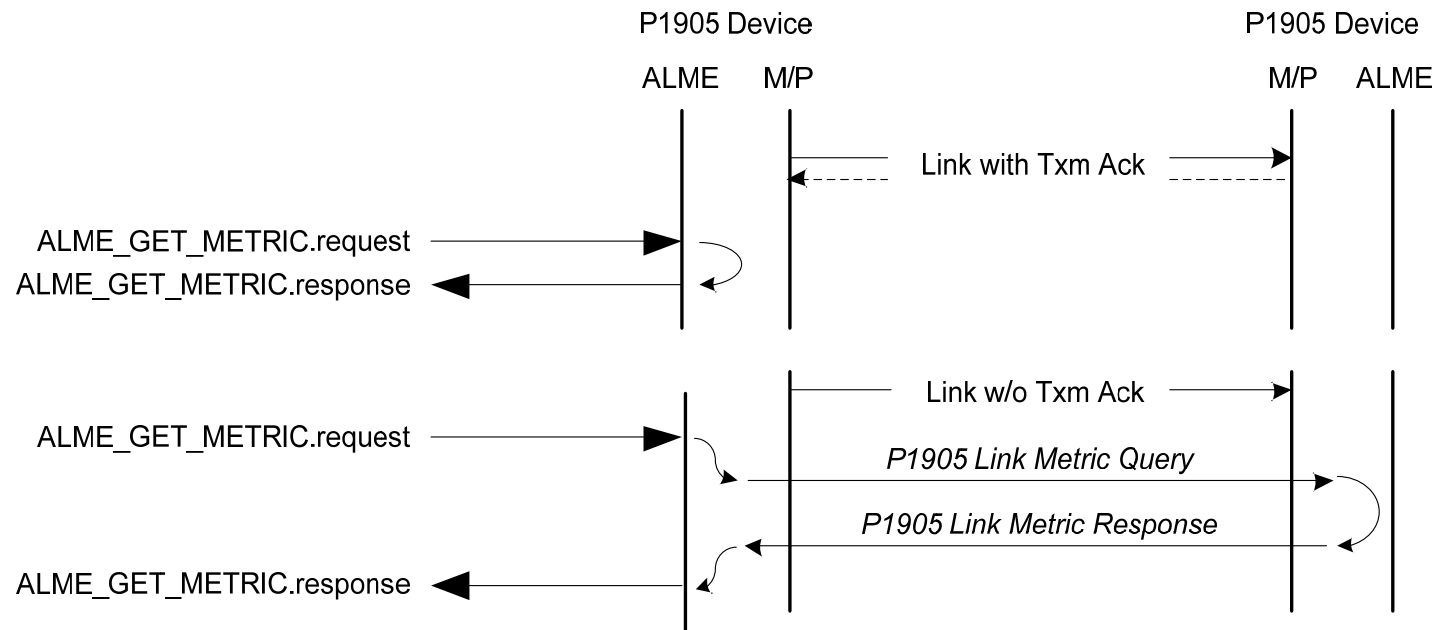*Underlying network Station Management Entities (SMEs) or specific management interfaces could be invoked directly.*

HLE

ALME_GET/SET

ALME_SAP

ALME

P1905.1 Abstraction Layer

Underlying MAC/PHY SME(s)

Underlying MAC/PHYs)

Control Plane

Data Plane
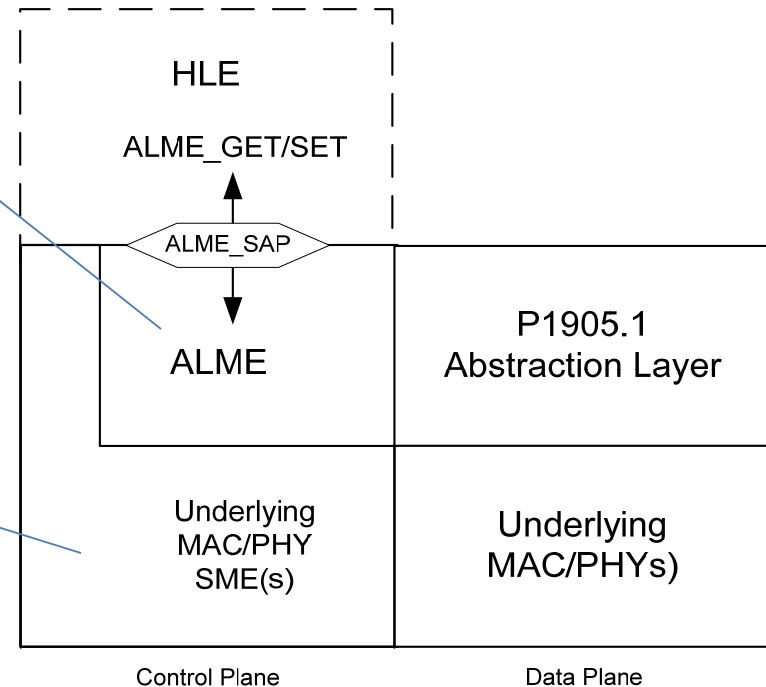
An example of what "abstracting" the underlying network technologies provides:

- ALME-GET-METRIC.response returns "Packet_Errors" stats (packet lost during txm) for transmission technology or transmission mode **with or without** transmission acknowledgement
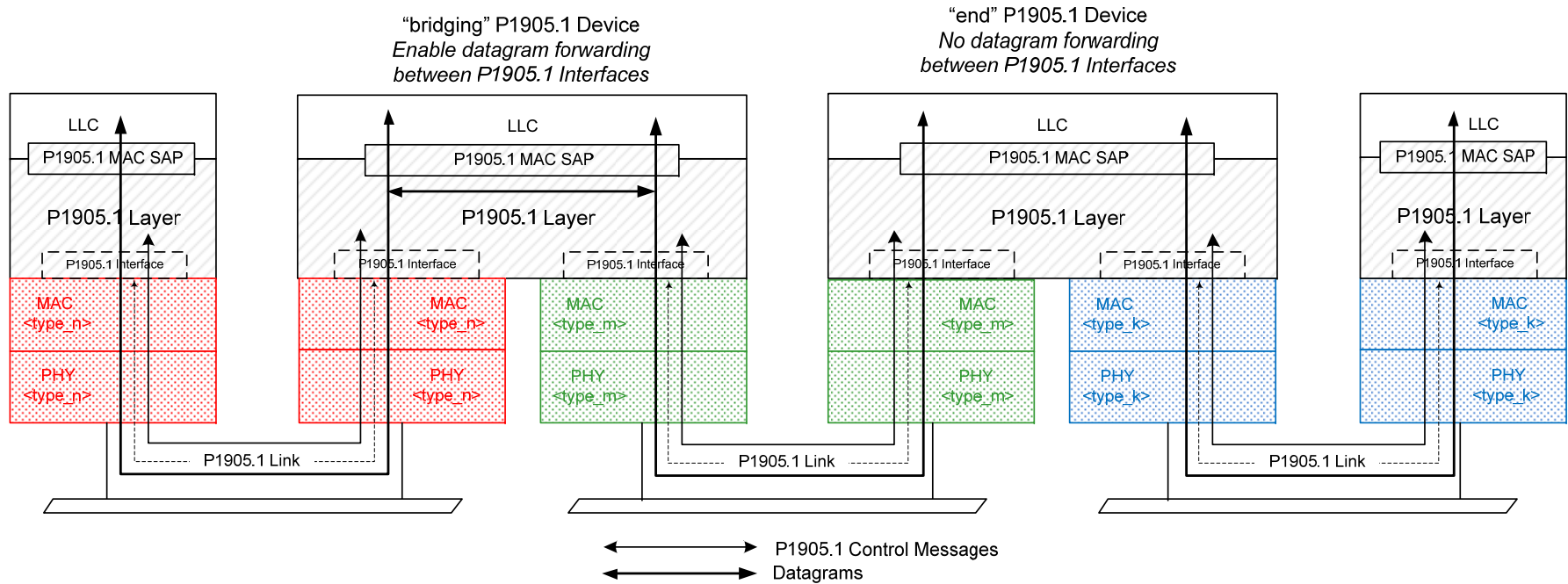
  [in the later case, the AL transparently queries the received stats from the link's receiver side to compute the Packet Errors stats from both the txm and rcv stats]

P1905.1 ALME Primitives

ALME Primitives		Description
ALME_GET_INTF_LIST	.request /.response	Enumerate the underlying network MAC/PHYs bound to the Abstraction Layer
ALME-SET-FWD-RULE ALME-GET-FWD-RULE ALME-MODIFY-FWD-RULE ALME-REMOVE-FWD-RULE	.request /.confirm .request /.response .request /.confirm .request /.confirm	Forwarding rules management *(more details in the P1905.1 MSDU Forwarding slides)*
ALME-GET-METRIC	.request /.response	Link Metric information
ALME-SET-INTF-PWR-STATE ALME-GET-INTF-PWR-STATE	.request /.confirm .request /.response	Power management

P1905.1 Network
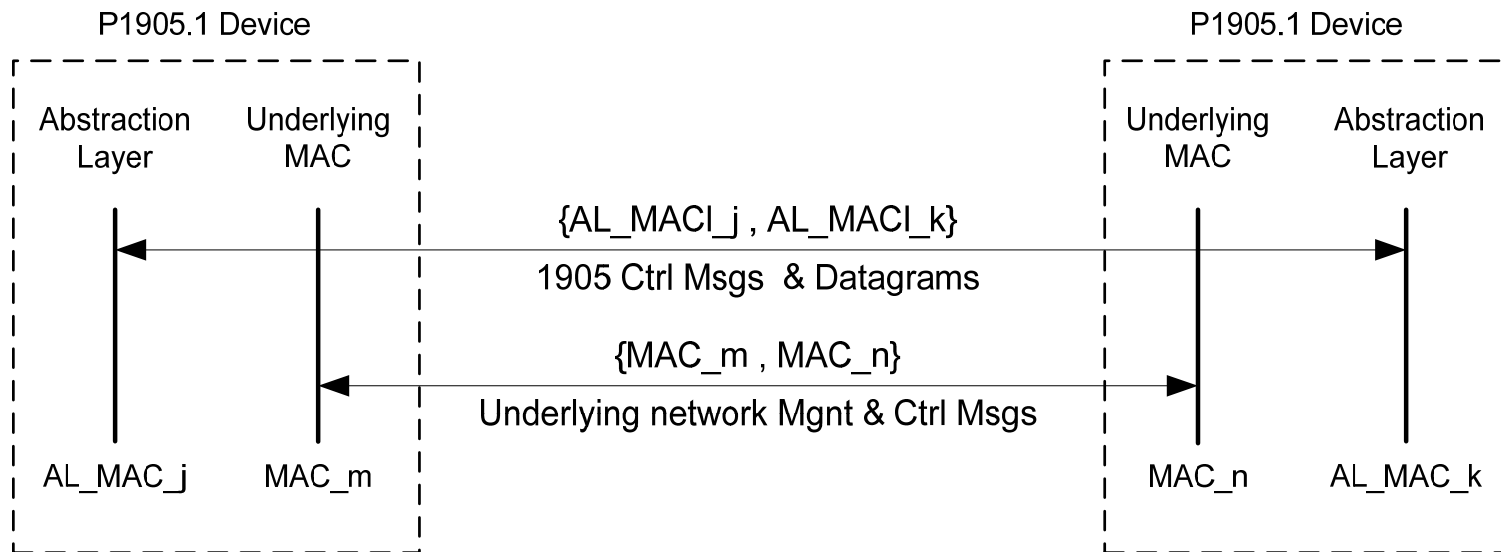
P1905.1 Definitions

P1905.1 Abstraction Layer   A layer between the LLC and one or multiple MAC SAPs of P1905.1 supported MAC/PHY Standards. Identified by its P1905.1 AL MAC address.

P1905.1 Device   A device with one or more interfaces abstracted by a P1905.1 Abstraction Layer.

P1905.1 Interface   An underlying P1905.1 network technology (MAC/PHY) .

P1905.1 Link   A logical link set by a P1905.1 management entity between the P1905.1 Abstraction Layer of two particular P1905.1 Devices through their respective P1905.1 Interfaces to exchange P1905.1 Control Messages Data Units (CMDUs) and MAC Service Data Units (MSDUs).

P1905.1 Network   A set of P1905.1 Devices interconnected by P1905.1 Links.

Neighbor P1905.1 Device   A P1905.1 device connected by at least one P1905.1 Link.

P1905.1 AL MAC Address

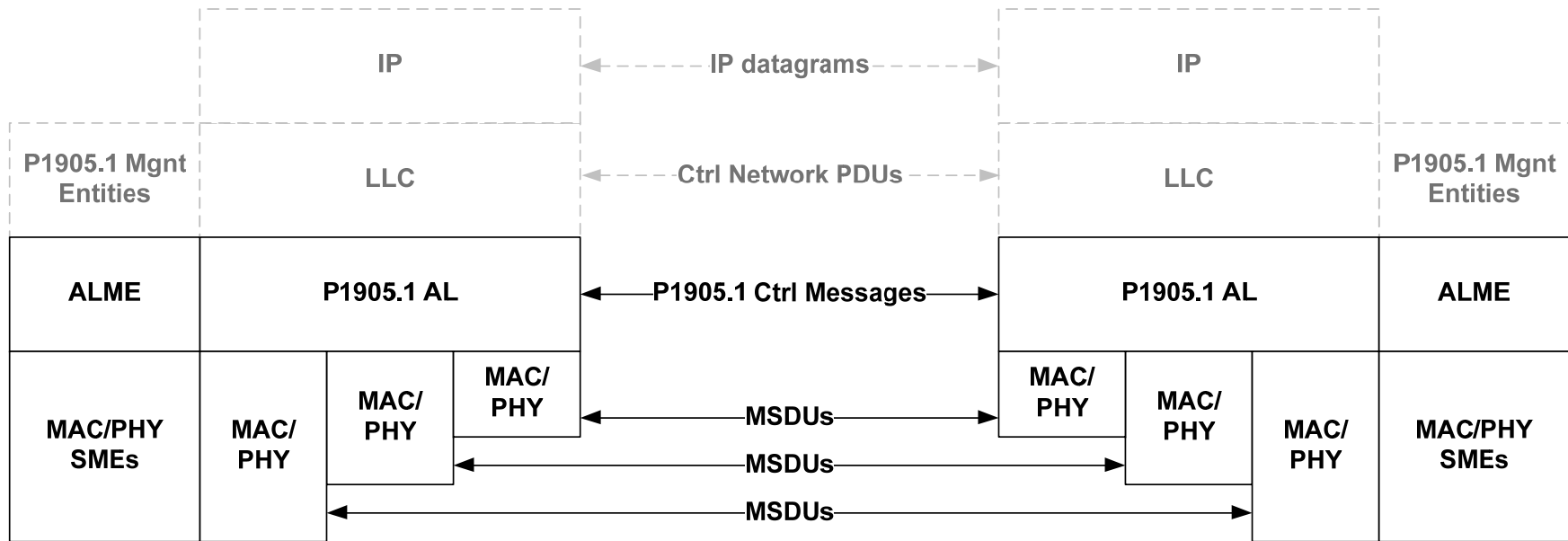- A P1905.1 Abstraction Layer within a P1905.1 Device uses a MAC Address for identification.

- The P1905.1 AL MAC Address is locally administered.

- The P1905.1 AL MAC Address may be used as a source and destination address for data and P1905.1 control packets destined for the device.

- Each P1905.1 AL shall use a MAC Address that is not used by any other P1905.1 AL in the P1905.1 Network to which it connects.

P1905.1 MAC Addressing

- Between P1905.1 Devices, MAC Service Data Units (MSDU) and CTRL Message Data Units (CMDU) are sent over the P1905.1 network using P1905.1 AL MAC Address as DA.

- Underlying interfaces may communicate using their generic MAC addresses, for control purposes.

P1905.1 Device

Abstraction Layer Underlying MAC

{AL_MACl_j , AL_MACl_k}

1905 Ctrl Msgs & Datagrams

{MAC_m , MAC_n}

Underlying network Mgnt & Ctrl Msgs

AL_MAC_j MAC_m

P1905.1 Device

Underlying MAC Abstraction Layer

MAC_n AL_MAC_k

P1905.1 Protocol Stack

P1905.1 MANAGEMENT PROTOCOL

P1905.1 Management Protocol

- Topology Discovery

- Populate an Internet Gateway Device data model for the CPE WAN Management Protocol 2 (TR-069)

- Common Security Setup

  Abstract the heterogeneous underlying network specific security setup into a common security setup procedure to enhance the user experience

- Management

- Diagnostics

- Enabler for enhanced power management

P1905.1 CMDU Txm Type

- Unicast: Addressed to a specific P1905.1 Device's AL MAC Address

- Multicast: P1905.1 Group Address

  - "Neighbor" Multicast: P1905.1 CMDU is terminated by the P1905.1 Device

  - "Relayed" Multicast: P1905.1 CMDU is propagated by the P1905.1 Device on its P1905.1 Interface(s)
  (but the ingress one)

CMDU = Control Message Data Unit

P1905.1 CMDU Protocol Procedures (1/3)

- Control Message Data Unit (CMDU) - Transmission

Event			Procedure
Control Message Data Unit (CMDU)	Transmission	Neighbor Multicast	• Transmit the CMDU once on each and every of its Authenticated P1905.1 Interfaces that would be reported in the "Device Information Type TLV" that are in the state of "PWR_ON" or "PWR_SAVE".
		Relayed Multicast	
		Unicast	• Select at least one of the Authenticated P1905.1 Interfaces connected to a P1905.1 Device addressed by the CMDU's Destination Address, where the Power State of the Device is at "PWR_ON" or "PWR_SAVE" and transmit the CMDU once the selected interface(s).

P1905.1 CMDU Protocol Procedures (2/3)

- Control Message Data Unit (CMDU) - Reception

Event			Procedure
Control Message Data Unit (CMDU)	Reception	Neighbor Multicast	If not previously received, and not locally generated, then : • Process the CMDU • Do not transmit the CMDU on any of its interfaces (since the "Relay Indicator" is not set).
		Relayed Multicast	If not previously received, and not locally generated, and "Relay Indicator" set in the CMDU header, then : • Process the CMDU • Retransmit the CMDU once on each of its interfaces on which it did not receive the CMDU.
		Unicast	If not previously received, and not locally generated, then : • Process the CMDU; • Do not transmit the CMDU on any of its interfaces.

P1905.1 Message Frame Format

Field	Length	Description
DA	6 octets	For unicast messages,: DA = the P1905.1 AL Address of the receiving P1905.1 device; *(if the sending device knows that the receiving interface is an 802.11 STA, then it may instead use as DA the MAC address of the receiving interface).* For multicast messages, DA = **P1905.1 Group address [01-80-C2-00-00-13]**
SA	6 octets	Implementation specific address
Ethertype	2 octets	**P1905.1 Ethertype [0x893A]**
Payload	46 – 1500 octets	P1905.1 Message
FCS	4 octets	Frame check sequence

P1905.1 Group address	01-80-C2-00-00-13
P1905.1 Ethertype	0x893A

P1905.1 Control Message Format

	Field	Length	Description
M s g H e a d e r	Message Version	1 octet	Message version. 0x00: for this version of the specification 0x01~0xFF: Reserved Values.
	Reserved field	1 octet	All values are reserved.
	Message Type	2 octets	*(cf next slide)*
	Message Identifier (MID)	2 octets	Identifies the message
	Fragment Identifier (FID)	1 octet	Identifies the fragment of a message
	Last Fragment Indicator	1 bit	'1': last fragment '0': not last fragment
	Relay Indicator	1 bit	Indicate if the message shall: '1': be relayed (Relayed Multicast) '0': not be relayed (Neighbor Multicast or Unicast)
	Reserved field	6 bits	
	P1905.1 Protocol TLVs	Variable length	TLV(s)
	End of Message TLV	3 octets	End of Message TLV

P1905.1 Control Message Type

Protocol	Message Type	Transmission Type	Description
Topology Discovery	Topology Discovery	Neighbor Multicast	Advertise a device's existence
	Topology Notification	Relayed Mutlicast	Notify of a device's change of topology
	Topology Query	Unicast	Query a device's topology information
	Topology Response	Unicast	Topology information in response to a topology query
	Forwarding Rule Query	Unicast	Query the P1905.1 AL Forwarding Rule information of a P1905.1 Device
	Forwarding Rule Response	Unicast	Carry the P1905.1 AL Forwarding Rule information in response to a Forwarding Rule query message
Push Button	P1905.1 Push Button Event Notification	Relayed Multicast	Advertise a push button event
	P1905.1 Push Button Join Notification	Relayed Multicast	Advertise a successful join due to a push button event
Extender AP-Auto configuration Protocol	AP-Autoconfiguration Search	Relayed Multicast	Search for a P1905.1 Registrar or a P1905.1 AP-enrollee
	AP-Autoconfiguration Response	Unicast	Answer to a Search Message
	AP-Autoconfiguration WPS	Unicast	Carry a WPS registration frame
	AP-Autoconfiguration Renew	Relayed Multicast	Advertise a renewing registration is required for a specific band
Link Metric Information	Link Metric Query	Unicast	Query the link metric information of a P1905.1 link between a specific device pair
	Link Metric Response	Unicast	Carry the link metric information in response to a link metric query
N/A	Vendor Specific	Unicast /Neighbor Multicast /Relayed Multicast	Vendor specific message

P1905.1 Topology Discovery Protocol

- 2 types of P1905.1 Topology protocol with different scope:

| Message	Scope
Topology Discovery	Neighbor Multicast
Topology Query	Unicast
Topology Response	Unicast
Topology Notification	Relayed Multicast

P1905.1 Device   P1905.1 Device   P1905.1 Device

Topology Discovery

Topology Discovery

Topology Discovery

Topology Discovery

Topology Query

Topology Response

Topology Notification

Topology Notification

Detection of "intermediate" IEEE 802.1D/Q Bridge

- A P1905.1 Device detects intermediate 802.1 D/Q Bridge(s) when it does not receive **both** a **LLDP message** and a **P1905.1 Topology Discovery** message **from the same source.**

1905 AL   1905 AL

S1   LLDP
S1   P1905 Discovery

802.1 D/Q Bridge w/o LLDP

S1   LLDP
S1   P1905 Discovery

802.1 D/Q Bridge w/ LLDP

S1   LLDP
     S2   LLDP
S1   P1905 Discovery

Message	MAC DA	802.1 D/Q Bridge FWD rule
LLDP	Nearest Bridge Group MAC Address	Not propagated
P1905.1 Discovery	P1905.1 Group MAC Address	Propagated

Common Network Setup (1/2)

- 3 Common Authentication Setup Methods :

1. **Push Button Configuration (PBC)**

   - Single PB initiates network specific native PCBs
   - Enables joining a new P1905.1 device to a network by pressing a button on the new device and on ANY in-network P1905.1 - whether or not they share a common network technology with the new device.

2. **Near Field Communication Network Key (NFCNK)**

   - A Key Carrying Device (KCD) is used to
     - generate and store a P1905.1 Network Key
     - distribute the P1905.1 Network Key to the P1905.1 Device

3. **User Configured Password (UCP)**

   - A single network password generates network specific passwords…
   - …used to initiate the underlying network specific native authentication protocols

P1905.1 Push Button Configuration
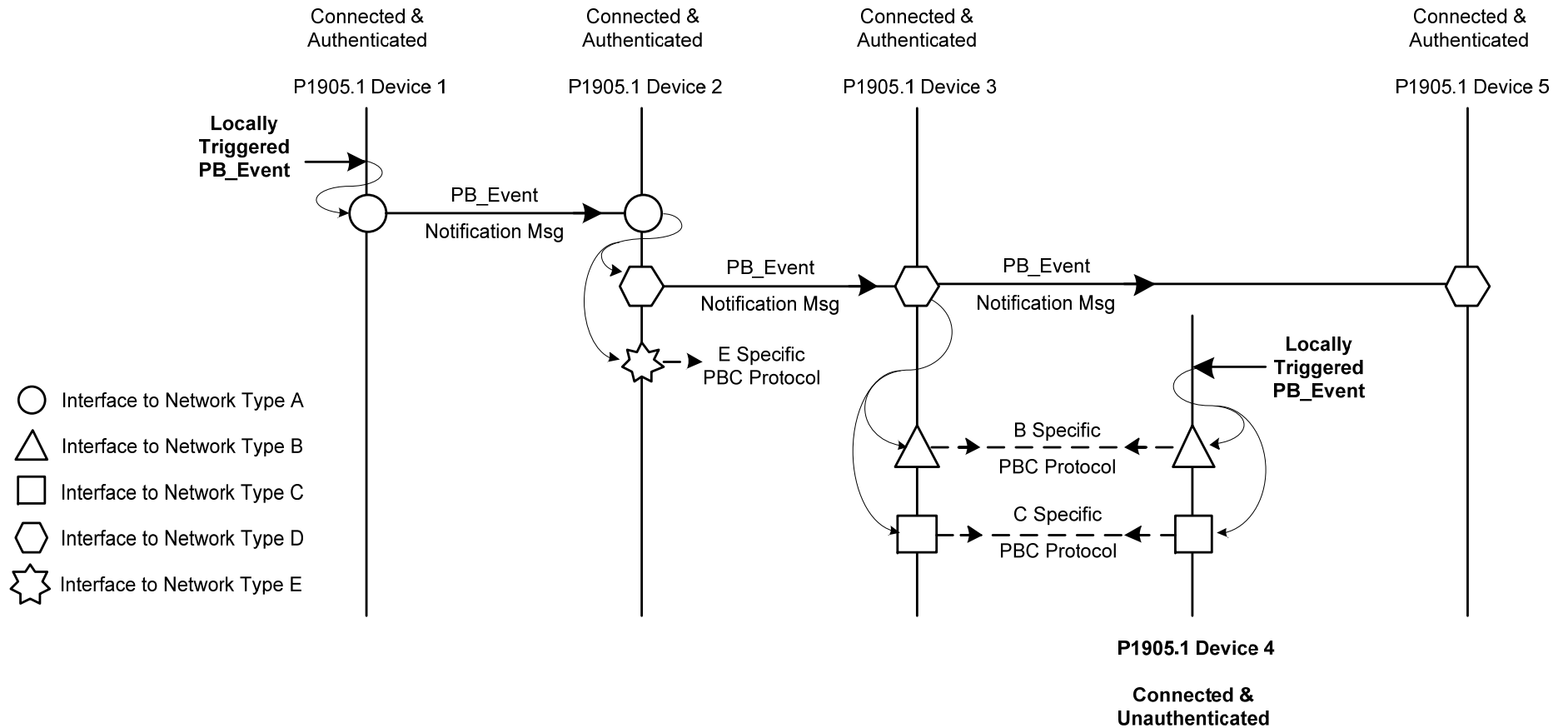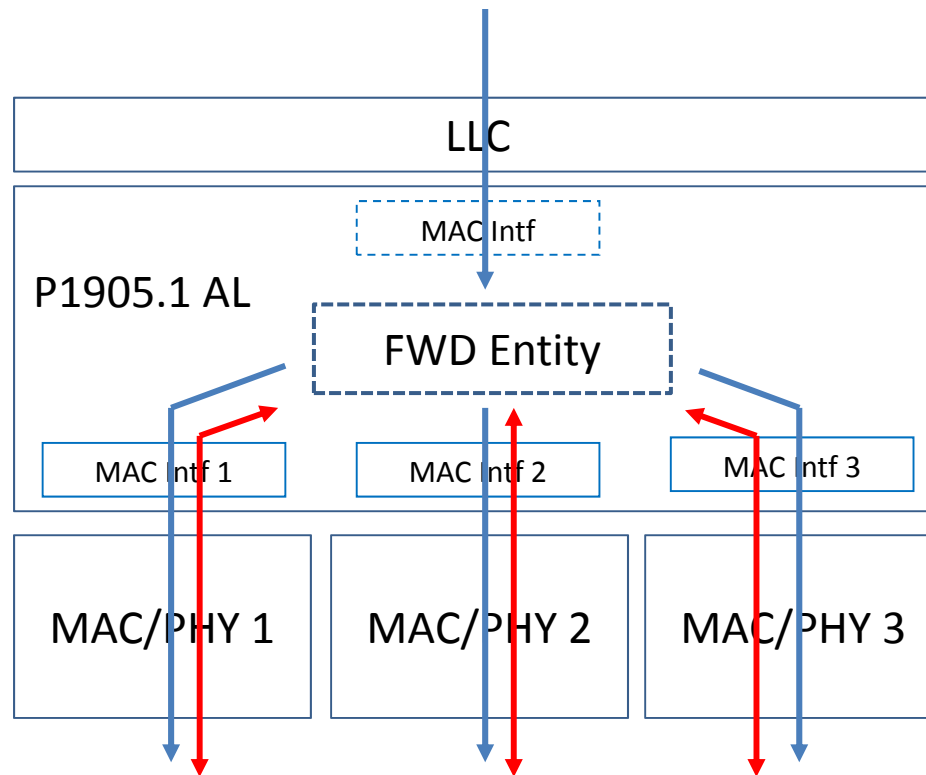
Common Network Setup (2/2)

- Extender AP Autoconfiguration
  - An "extender AP" is a secondary unconfigured IEEE 802.11 AP, added to the 1905.1 network to increase the home coverage.
  - The AP Autoconfiguration protocol allows the extender AP to be automatically configured with the configuration of a primary configured IEEE 802.1 AP, transferred in a secure manner.
  - The AP Autoconfiguration protocol encapsulates the Wi-Fi Protected Setup (WPS) protocol in P1905.1 CMDUs.

    WPS conveys Wi-Fi parameters from an AP-Registrar to an AP-Enrollee to setup the initial configuration or renew an existing configuration of a Wi-Fi interface.
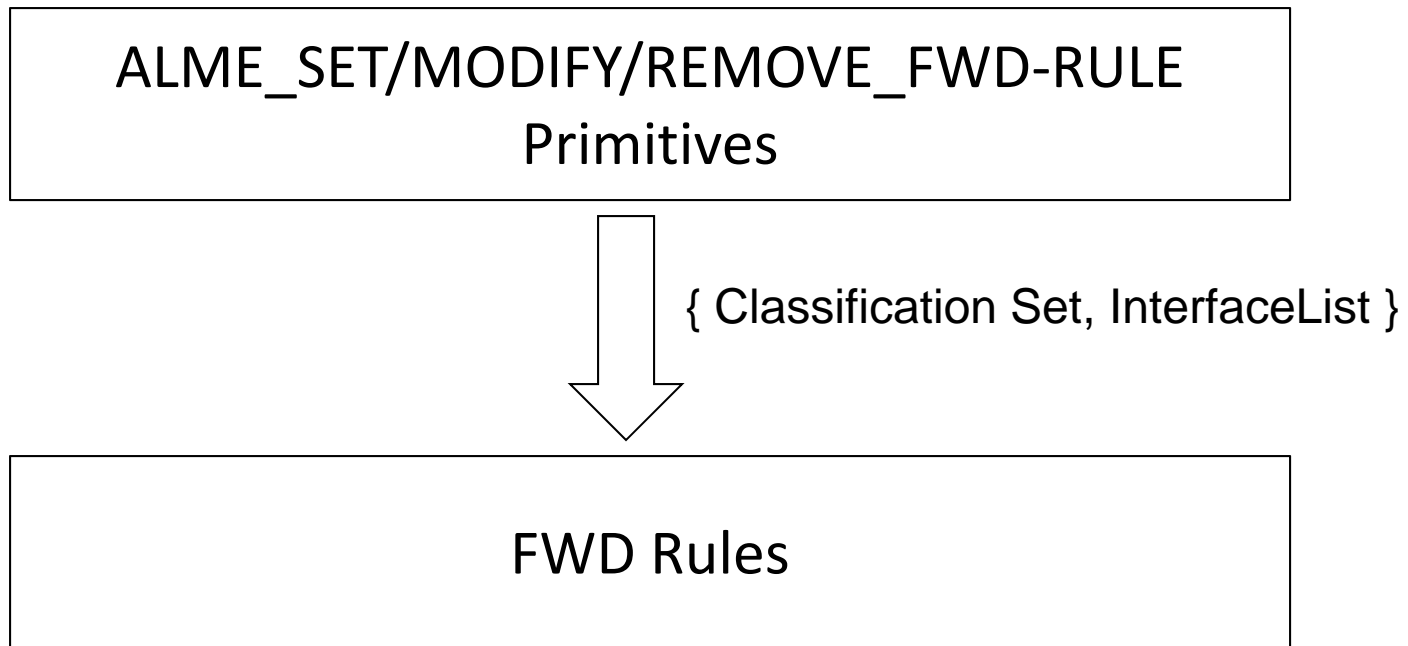
P1905.1 MSDU FORWARDING

P1905.1 AL - MSDU Forwarding

- "The behavior of a P1905.1 Device's forwarding entity is **not** defined in the P1905.1 standard **but shall be interoperable with IEEE 802.1 bridging**"

P1905.1 Forwarding Rules Management

```
┌──────────────────────────────────────────────┐
│  ALME_SET/MODIFY/REMOVE_FWD-RULE              │
│  Primitives                                    │
└──────────────────────────────────────────────┘
                   │
                   ▼   { Classification Set, InterfaceList }
┌──────────────────────────────────────────────┐
│                                                │
│              FWD Rules                         │
│                                                │
└──────────────────────────────────────────────┘
```

P1905.1 ClassificationSet Elements

Name	Type	Valid Range	Description
DA	EUI-48 Address	Any address	Destination Address
macDaFlag	*BOOLEAN*	*TRUE, FALSE*	*If FALSE, the DA element is ignored*
SA	EUI-48 Address	Any address	Source Address
macSaFlag	*BOOLEAN*	*TRUE, FALSE*	*If FALSE, the SA element is ignored*
EtherType	Integer	As defined in the IEEE EtherType Field Public Listing	EtherType
ethertypeFlag	*BOOLEAN*	*TRUE, FALSE*	*If FALSE, the EtherType element is ignored*
VID	Integer	As defined in 802.1Q frame format	IEEE 802.1Q VLAN ID
vidFlag	*BOOLEAN*	*TRUE, FALSE*	*If FALSE, the element is ignored*
PCP	Integer	As defined in 802.1Q frame format	IEEE 802.1Q Priority Code Point field
pcpFlag	*BOOLEAN*	*TRUE, FALSE*	*If FALSE, the element is ignored*

P1905.1 ALME FWD Primitives

FWD Rule Management	
ALME-SET-FWD-RULE.[request|confirm]	{classificationSet(s), intfList | ruleID}
ALME-GET-FWD-RULE.[request|response]	{ruleID | classificationSet(s), intfList}
ALME-MODIFY-FWD-RULE.[request|confirm]	{ruleID, intfList}
ALME-REMOVE-FWD-RULE.[request|confirm]	{ruleID}

Link Metrics *To enhance path selection, the ALME provides an API to query the metric information of the underlying P1905.1 links*	
ALME-GET-METRIC.[request|response]	*{AL MACAddress | metrics}*

Summary (1/2)

- *Different connectivity technologies are deployed in the homes, each with its own advantages and impairments*

- *Today, home networks are NOT managed...*

- *.. and while relatively simple in the past, their complexity have dramatically increased with the fast deployment of heterogeneous connected devices.*

Summary (2/2)

- As a first step, P1905.1 adds :
  - some **visibility** (topology discovery, diagnostics, link metrics)
  - **simplified setup** (common security setup method, automated configuration of a secondary Wi-Fi AP, power management)
- The visibility via P1905.1 may provide guidance on when/how to do provide network manageability in the home.

- **P1905.1 works with companion technologies such as 802.1 to provide a synergistic solution.**

QUESTIONS ?

THANK YOU

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P1905.1 PAR - Scope

- The standard defines an abstraction layer for multiple home networking technologies.

- The abstraction layer provides a common data and control Service Access Point to the heterogeneous home networking technologies described in the following specifications: IEEE P1901, IEEE 802.11, IEEE 802.3 and MoCA 1.1. The standard is extendable to work with other home networking technologies.

- The abstraction layer supports dynamic interface selection for transmission of packets arriving from any interface (upper protocol layers or underlying network technologies). End-to-end Quality of Service (QoS) is supported.

- Also specified are procedures, protocols and guidelines to provide a simplified user experience to add devices to the network, to set up encryption keys, to extend the network coverage, and to provide network management features to address issues related to neighbor discovery, topology discovery, path selection, QoS negotiation, and network control and management.

P1905.1 PAR - Purpose

- The abstraction layer common interface allows applications and upper layer protocols to be agnostic to the underlying home networking technologies. The purpose of the standard is to facilitate the integration of P1901 with other home networking technologies.

- Additionally the purpose of the standard is to define an abstraction layer that allows: Common Network Setup among heterogeneous network technologies defined in the PAR and provide same user experience in the process of adding a device to the network and the same user experience while setting an encryption key; Intelligent network interface and support for path selection for delivery of packets that provides improved coverage performance, improved data rate on poorest link, Improved network capacity, Improved network reliability and QoS, support for end-to-end Quality of Service (QoS) for different traffic classes; Seamless / transparent path switching; Real time mapping of connection links and paths for each traffic class / stream; Green - energy management.