IEEE 802 Local Addressing for AI Networks

IEEE 802.1-26-0001-01-ICne

Venue: Joint meeting of IEEE 802.3 New Ethernet Applications (NEA) and IEEE 802 Nendica
19 January 2025
Austin, USA

Roger Marks <roger@ethair.net>
EthAirNet Associates
+1 802 capable

~~15~~19 January 2026

Overhead in Small Frames

- It has been reported [1] that GPU scale-up networking uses a “typical” payload of 128 or 256 B.
- The Ethernet MAC frame includes two 6-byte addresses, which (along with higher-layer overhead) may be significant in a small frame.
  - Ethernet maxBasicDataSize = 1500 B

Perceived goal: Reduce overhead in smaller frames.

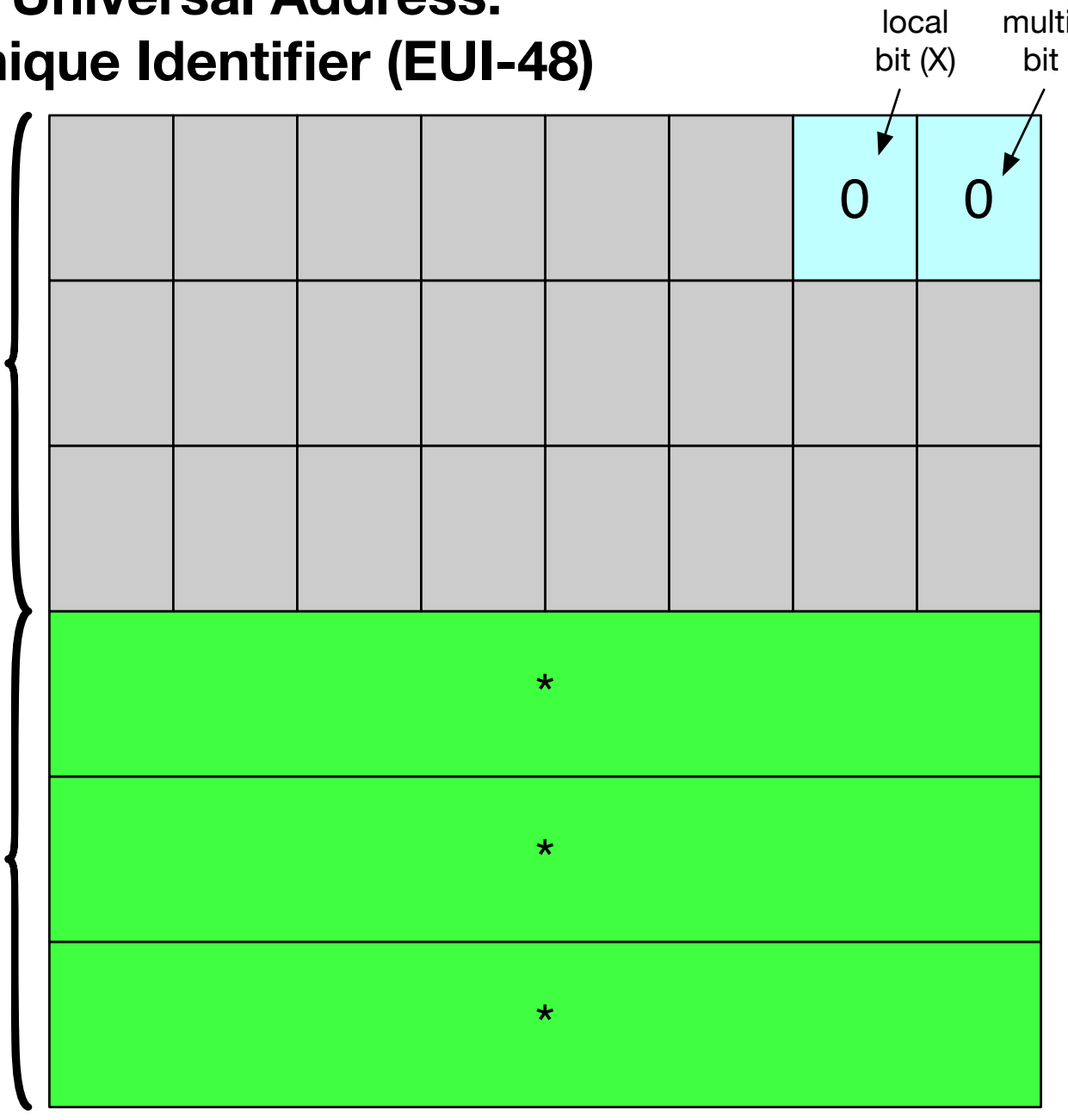
Note: Can also pack multiple payloads into a larger frame.

- possible side effects, including latency
- [3] considers opportunistic packing
  - packing, up to 4096 B, when multiple payloads to a destination are simultaneously available to send
  - still, many frames are expected to be small

“Efficient Headers”

- It has been reported [1,2] that several organizations are considering plans for “efficient headers” for frame compression.
  - carry information other than MAC addresses in Ethernet MAC address fields
- [3] describes the “AI Fabric Header Gen 2” frame in which MAC Source Address (SA) and Destination Address (DA) fields each carry upper-layer info
  - except four bits of DA field set per IEEE Std 802
- How does this fit with IEEE Std 802?

IEEE 802 Universal Address: Extended Unique Identifier (EUI-48)



OUI assigned by IEEE Registration Authority (RA), typically to manufacturer

assigned by assignee of OUI, typically

so universal address is globally unique [4]

"Allocation of a single EUI-48 identifier to identify or permit addressing of a fixed and permanent function associated with a real item of physical equipment occurs for the lifetime of that equipment or an indefinite period of use." [5]

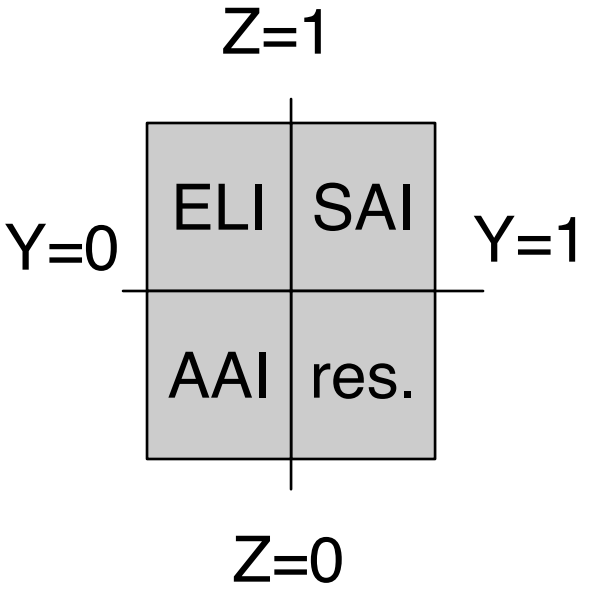
Information content of IEEE 802 Universal Address

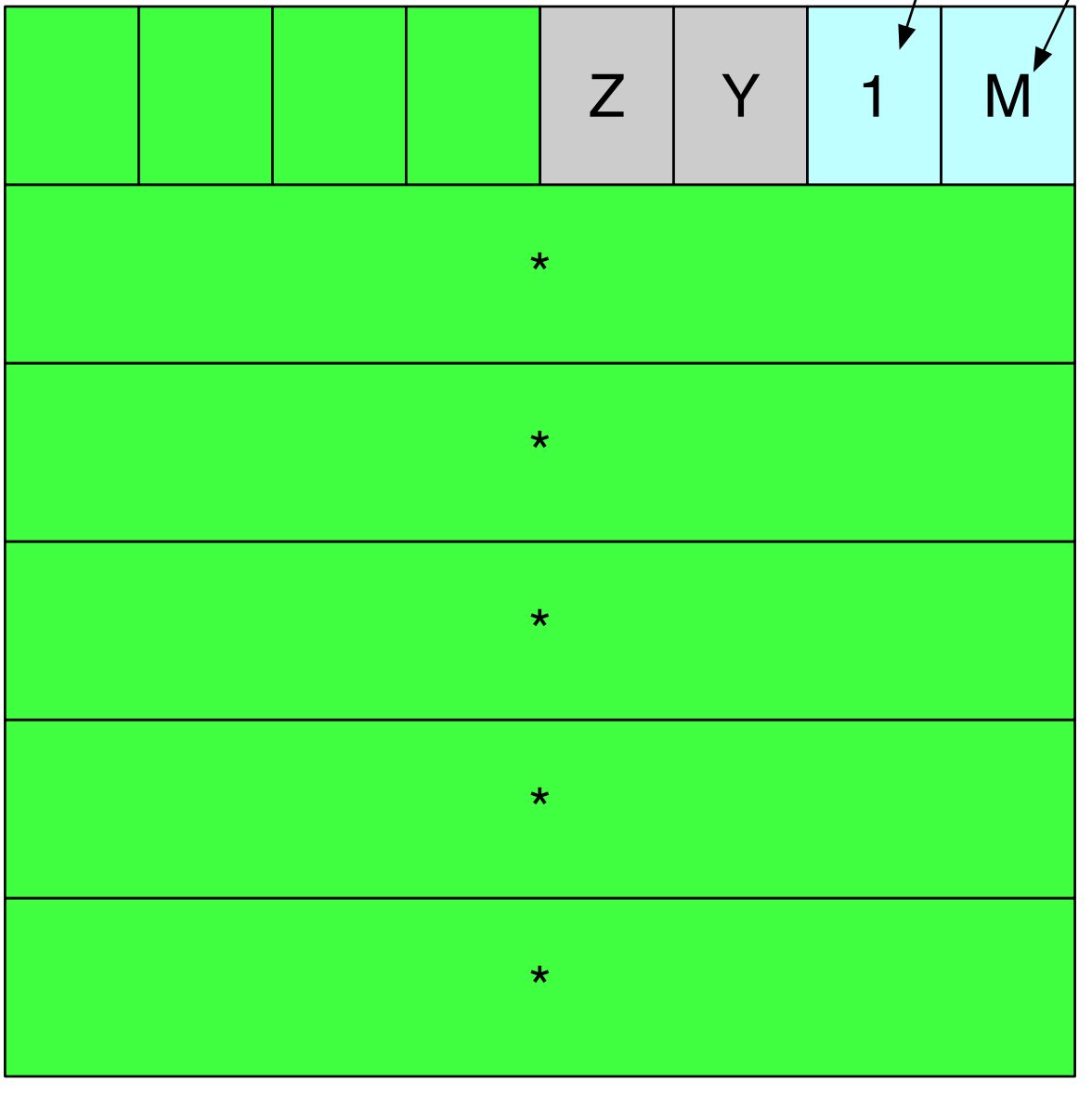
- Information burned in as universal address:
  - OUI (provides hint at manufacturer)
  - the specific piece of hardware
  - nothing else!
    - not device type
      - except OUI-specific scheme
    - not device configuration
    - not location in network
    - etc.

IEEE 802 Local Addresses

- Half of IEEE 802 address space is local
  - when the "X" bit is 1
- IEEE RA began promoting local addresses in ~2010
  - structured local space using Company ID (CID)
- IEEE 802.1 Working Group ran Local Address Study Group (2014-2015) [6]:
  - "Structuring of local space offers opportunity for new switching methods that might work better in some circumstances… Structure needs to be standardized so switches can understand addresses." [7]
- IEEE Std 802 introduced Structured Local Address Plan (SLAP) [8] via amendment IEEE Std 802c-2017
  - developed in 802.1 WG's Data Center Bridging Task Group
- IEEE Std 802c incorporated in IEEE Std 802-2024 [4]

IEEE 802 Local Address (48 bit) per Structured Local Address Plan (SLAP)





SLAP Quadrants and Identifiers

ELI-48	Extended Local Identifier	24 bits assigned by IEEE RA as CID	24 bits assignable by assignee of CID
AAI-48	Administratively Assigned Identifier	4 bits assigned by IEEE Std 802	44 bits assignable by local administrator
SAI-48	Standard Assigned Identifier	4 bits assigned by IEEE Std 802 additional bits assigned to differentiate standards	<44 bits assignable to specific standard

SLAP Concepts, per IEEE Std 802 [4]

- *locally administered bits of local MAC addresses are arbitrarily assignable under the condition that local MAC addresses are unique within a LAN*
- *Administrators who deploy multiple protocols on a LAN in accordance with the SLAP enable the unique assignment of local MAC addresses within the LAN as long as each protocol maintains unique assignments within its own address subspace.*
- *Unlike universal addresses, which are persistent to the MAC entity, local MAC addresses are not necessarily persistent.*
- *Multiple protocols for assigning SAI may be specified within various IEEE 802 standards. Coexistence of such protocols may be supported by restricting each to assignments within a subspace of SAI space.*
- *In some cases, an SAI assignment protocol may assign the SAI to convey specific information. Such information may be interpreted by receivers and bridges that recognize the specific SAI assignment protocol, as identified by the subspace of the SAI. The functionality of receivers and bridges that do not recognize the protocol is not affected. SAI address formats, and their interpretation, are outside the scope of this standard but may be specified in other IEEE 802 standards.*

Example per [3]

- In the “AI Fabric Header Gen 2” frame of [3]:
  - - the MAC DA field is formatted as an AAI
  - a subfield of the DA is a destination identifier
  - forwarding should use the destination identifier subfield, not the DA; with normal 802.1Q [9] forwarding, the switch would need to store many addresses of the same destination identifier
- the MAC SA field is not formatted per IEEE Std 802
  - X bit is not set to indicate whether the SA is universal or local
    - If universal, then it misappropriates a non-owned EUI-48.
  - M bit is not set to indicate whether the SA is unicast or multicast
    - Per IEEE 802.3 [10], “The Source Address field specifies the station sending the MAC frame.” [i.e., not a multicast address]
  - Per 802.3, “The Source Address field is not interpreted by the MAC sublayer.” But normal 802.1Q operations would be problematic if switch tried to learn the port of each SA.
    - see the following slide

802.1Q on Bridge Learning

When invoked, the Learning Process shall create or update a Dynamic Filtering Entry (8.8.3) that specifies the reception Port for the frame's source address and, in the case of VLAN Bridge components, the frame's VID, if and only if the source address is an individual address, i.e., is not a group address, the resulting number of entries would not exceed the capacity of the FDB, and the filtering utility criteria for the receiving Bridge Port are met, as specified below.

This is a little hard to parse, but it apparently says that the Bridge is excluded from learning a multicast SA.

Therefore, if the content of the SA field is NOT a source address, it might be wise to set the multicast bit.

Local Address Standardization

- [1] suggests a “uniform standard to regulate the format and usage of efficient forwarding headers” for “ensuring compatibility across vendors.”
- Per the SLAP, standardization of MAC addresses within IEEE 802 should be within SAI
  - incompatible implementations would be distinguished by some additional bits
  - this would leave fewer bits available for each standard
- EtherType could provide additional information
  - particularly via subtype (see [4] § 9.2.3)

Local Address Assignment

- As noted above, [4] says that the locally administered bits of local MAC addresses are arbitrarily assignable *under the condition that local MAC addresses are unique within a LAN*
- That condition suggests that assignment of the destination identifiers to the elements needs to be done carefully.
- Dynamic assignment might be preferred.
- Methods of dynamically assigning local addresses have been proposed; e.g. [11].

Local Addressing in Scale-Out

- Local addressing has also been studied in structured scale-out networks, such as Clos fat-tree [12]
  - [12] shows that semantic assignment of structured local addresses can enable stateless switching, without the need for forwarding tables
    - in a network of tens of millions of servers
    - forwarding entirely within Layer 2
  - the address assignment method of [11] assigns, to a device, a block of addresses
    - enables, e.g., MAC addresses that individually address virtual machines with a common server identifier

Multicast Local Addressing

- SLAP includes multicast as well as unicast.
- The address block assignments of [11] include multicast as well as unicast addresses.
- It has been shown that such blocks can support the dynamic creation of multicast groups that can be used for efficient collection communication models such as those prevalent in AI networks [13].
  - forwarding entirely within Layer 2

Conclusion

- Local addressing allows dynamic addresses with semantic content
- Local addressing can support AI networking functionality
- IEEE 802 standards support local addressing, multicast as well as unicast
- Enhancement of IEEE 802 standards may be useful to promote successful coexistence among alternative protocols
- Enhancement of IEEE 802 standards may be useful to specify new protocols

References (1/2)

[1] R. Hu, et al., "The Requirement of Standardizing Efficient MAC Header for AI Cluster Network" IEEE 802 Nendica contribution 1-25-0021 (Dec 2025)
- https://mentor.ieee.org/802.1/documents?is_group=ICne&is_year=2025&is_dcn=0021

[2] P. Congdon, "AICN Insights from OCP Global Summit 2025" IEEE 802 Nendica contribution 1-25-0017 (Nov 2025)
- https://mentor.ieee.org/802.1/documents?is_group=ICne&is_year=2025&is_dcn=0017

[3] Broadcom, "Scale-Up Ethernet Framework Specification" Scale-Ethernet-RM104 (Sep 2025)
- https://docs.broadcom.com/doc/scale-up-ethernet-framework

[4] IEEE Std 802-2024

[5] IEEE Registration Authority, "Guidelines for Use of Extended Unique Identifier (EUI), Organizationally Unique Identifier (OUI), and Company ID (CID)" (Aug 2017)
- https://standards.ieee.org/products-programs/regauth/tut/

[6] 802.1 Local Address Study Group
- https://1.ieee802.org/archives/lasg/

[7] R. Marks, "Opportunities for New IEEE 802 Switching Protocols in Local Space" (Jan 2015)
- https://ieee802.org/1/files/public/docs2015/lasg-marks-local-address-switching-0115-v00.pdf

References (2/2)

[8] R. Marks, “802c Update” (July 2016)

- https://ieee802.org/1/files/public/docs2016/802c-Marks-RAC-update-0716.pdf

[9] IEEE Std 802.1Q-2022

[10] IEEE Std 802.3-2022

[11] R. Marks, “Link-Layer Software-Defined Addressing using Block Address Registration and Claiming (BARC),” 2021 IEEE Conference on Standards for Communications and Networking

- https://ieeexplore.ieee.org/document/9686182

[12] S. Gonzalez-Diaz, R. Marks, E. Rojas, A. de la Oliva and R. Gazda, “Stateless Flow-Zone Switching Using Software-Defined Addressing," *IEEE Access* (May 2021)

- https://ieeexplore.ieee.org/document/9424558

[13] R. Marks, “Collective Communication in a Layer 2 Clos Fat-tree," IEEE 802 Nendica contribution 1-24-0012 (Mar 2024)

- https://mentor.ieee.org/802.1/documents?is_group=ICne&is_year=2024&is_dcn=0012