

# Guidelines for Use of Extended Unique Identifier (EUI), Organizationally Unique Identifier (OUI), and Company ID (CID)

## Abstract

This tutorial covers organizational identifiers assigned by the IEEE Registration Authority (IEEE RA) and extended identifiers based on them. It covers identifier formats, assignment, guidelines, and policies relevant to assignees as well as to standards developers. The tutorial includes information relevant to organizational identifiers, such as Organizationally Unique Identifier (OUI) and Company ID (CID), and to extended identifiers such as the Extended Unique Identifier (EUI) and Extended Local Identifier (ELI).

## Status and History

This tutorial supersedes the following three IEEE RA tutorial documents:

- Guidelines for Use Organizationally Unique Identifier (OUI) and Company ID (CID)
- Guidelines for 48-Bit Global Identifier (EUI-48)
- Guidelines for 64-bit Global Identifier (EUI-64)

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### IEEE-Administered organizational identifiers: OUI and CID

The IEEE Registration Authority (IEEE RA) assigns globally unique identifiers to organizations. Two types of identifier– the 24-bit Organizationally Unique Identifier (OUI) and the 24-bit Company ID (CID)– are related to each other in that they come from the same 24-bit space but fall in different subspaces, as distinguished by a particular bit known as the X bit, as shown in Table 1. The X bit location is shown in Figure 1. Each assigned OUI and CID and is unique with respect to all assigned OUIs and CIDs<sup>1</sup>.

Table 1: 24-bit CID/OUI space divided into two subspaces

X bit	identifier
0	OUI
1	CID

An OUI or a CID may be used for identification of a company, organization, entity, manufacturer, vendor, etc.

The IEEE Registration Authority also recognizes and assigns a 36-bit OUI-36 as a globally unique identifier of an organization. The first 24 bits of the assigned OUI-36 do not duplicate any OUI or CID assignment.

### OUI

The OUI is a 24-bit (three octet) sequence. The structure of an OUI is shown in Figure 1. Octet 0 is the initial (most significant) octet. The least and second least significant bits of Octet 0 are designated the M bit and X bit, respectively. In the OUI, both the M and X bit have the value 0.

NOTE – Approximately 18 organizational identifiers assigned to early Ethernet implementers (some of the BlockID assignments made prior to approval of IEEE Std 802.3-1985) have the X bit equal to 1. The BlockID, like the OUI that replaced it, was a 24-bit number that served as the base for a block of  $2^{24}$  48-bit MAC addresses. The BlockID assignments are recorded in the MA-L (OUI) registry.

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<sup>1</sup> The IEEE Registration Authority makes a concerted effort to avoid duplicate assignments but does not guarantee that duplicate assignments have not occurred. Global uniqueness also depends on proper use of assignments and absence of faults that might result in duplication.

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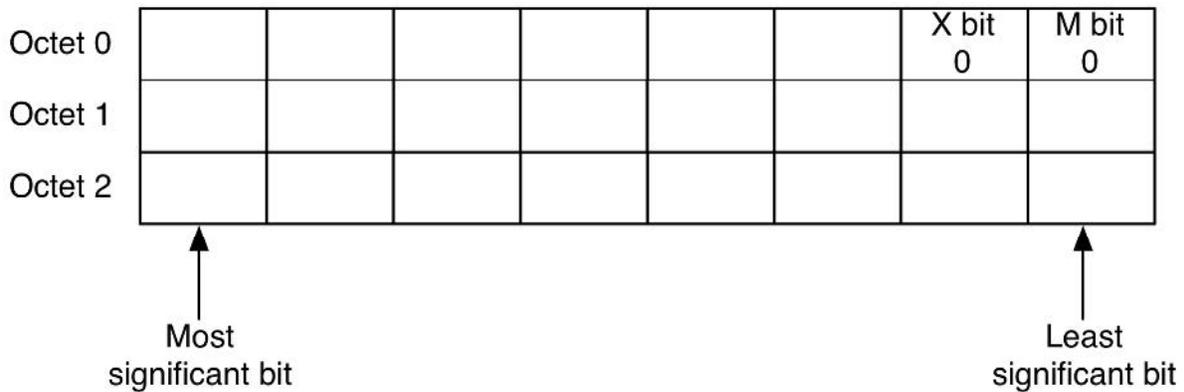


Figure 1: Structure of an OUI

The OUI can be represented as a base-16 number of six hexadecimal digits. Alternatively, it can be represented as octets separated by hyphens; the IEEE RA refers to this as the hexadecimal (hex) representation. Table 2 displays an example of the OUI with the base-16 form "ACDE48" and the hex representation "AC-DE-48"<sup>2</sup>. The last row of Table 2 represents the 24-bit binary OUI sequence.

Table 2: Example OUI

octet identifier	0	1	2
example value (hex)	AC	DE	48
example value (binary)	<div style="display: flex; justify-content: space-between; font-size: small;"> <span>MSB</span> <span>LSB</span> </div> 1010 1100	1101 1110	0100 1000

### OUI-36

The OUI-36 is a 36-bit (four-and-one-half-octet) sequence. Octet 0 is the initial (most significant) octet. The least and second least significant bits of Octet 0 are designated the M bit and X bit, respectively. In the OUI-36, both the M and X bit have the value 0.

An OUI-36 assignment may be used where a 36-bit organization identifier or 36-bit protocol identifier is needed. For example, some protocols specify 36-bit identifiers to identify either an organization or objects specified by that organization. The assignee of an OUI may create an OUI-36 by adding 12 bits to the end of the assigned OUI. If the assignee of an OUI-36 needs a unique 24-bit organization identifier, a CID assignment is recommended.

<sup>2</sup> This example octet string could be in use and is not a reserved value.

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The OUI-36 can be represented as a base-16 number of nine hexadecimal digits. Alternatively, it can be represented as octets separated by hyphens, using the IEEE RA hexadecimal (hex) representation. Table 3 displays an example of the OUI-36 with the base-16 form "ACDE48234" and the hex representation "AC-DE-48-23-4". The last row of Table 3 represents the 36-bit binary OUI-36 sequence.

Table 3: Example OUI-36

octet identifier	0	1	2	3	4
example value (hex)	AC	DE	48	23	4
example value (binary)	<small>MSB</small> 1010 : 1100	1101 : 1110	0100 : 1000	0010 : 0011	<small>LSB</small> 0100

An OUI-36 is created by the IEEE RA by concatenating 12 bits to a 24-bit IEEE-reserved base OUI, concatenating these 12 bits after the least significant bit of Octet 2, as shown in Figure 1. The base OUI will not be assigned to another organization or otherwise be used as an OUI. An assignee of an OUI-36 shall not truncate the OUI-36 to use as an OUI because the IEEE RA will use the base OUI to assign OUI-36 values to multiple organizations.

No presumptions should be made regarding the base OUI. For example, it should not be presumed that multiple OUI-36 assignments to a single organization will share a common base OUI.

### CID

The CID is a 24-bit (three-octet) sequence. The structure of a CID is shown in Figure 2 below. Octet 0 is the initial (most significant) octet. The four least significant bits of Octet 0 are designated the M bit, X bit, Y bit, and Z bit, respectively, beginning with the least significant bit. In the CID, the M, X, Y, and Z bits have the values 0, 1, 0, and 1, respectively.

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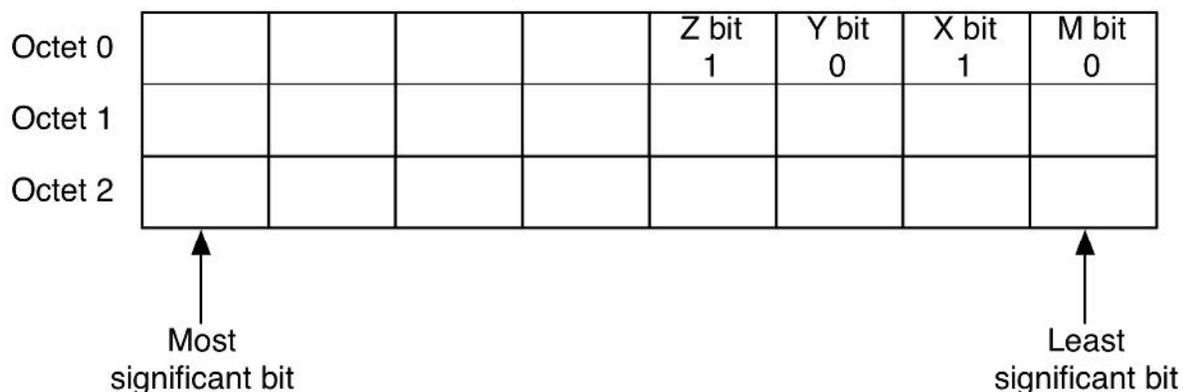


Figure 2: Structure of a CID

The CID can be represented as a base-16 number of six hexadecimal digits. Alternatively, it can be represented by octets separated by hyphens, in the IEEE RA hexadecimal (hex) representation. Table 4 displays an example of the CID with the base-16 form "AADE48" and the hex representation "AA-DE-48"<sup>3</sup>. The last row of Table 4 represents the 24-bit binary CID sequence.

Table 4: Example CID

octet identifier	0	1	2
example value (hex)	AA	DE	48
example value (binary)	<div style="display: flex; justify-content: space-between; font-size: 8px;"> <span>MSB</span> <span>LSB</span> </div> 1010 : 1010	1101 : 1110	0100 : 1000

### Extended Identifiers

In addition to serving as a globally unique organization identifier, an OUI, OUI-36, or CID may also be used as the basis of extended identifiers, including protocol identifiers and context dependent identifiers, by concatenating additional differentiating bits. These extended identifiers might be globally unique (e.g., EUI-48 and EUI-64) or only unique within the context in which they are used. Details are provided below.

### Extended Unique Identifiers

An Extended Unique Identifier (EUI) is either a 48-bit Extended Unique Identifier (EUI-48) or a 64-bit Extended Unique Identifier (EUI-64). With some

<sup>3</sup> This example octet string could be in use and is not a reserved value.

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exceptions, particularly with regard to protocol identifiers, each EUI is intended to be globally unique and bound to a hardware device instance or other object that requires unique identification. EUI-48 and EUI-64 identifiers are most commonly used as globally unique network addresses (sometimes called MAC addresses), as specified in various standards. For example, an EUI-48 is commonly used as the address of a hardware interface according to IEEE Std 802, historically using the name "MAC-48". As another example, an EUI-64 may serve as the identifier of a clock, per IEEE Std 1588. IEEE Std 802 also specifies EUI-64 use for 64-bit globally unique network addresses. Further detail regarding EUI-48 and EUI-64 is provided below.

When an EUI is used as a MAC address (for example, an IEEE 802 network address), the two least significant bits of the initial octet (Octet 0) are used for special purposes. The least significant bit of Octet 0 (the I/G bit) indicates either an individual address (I/G=0) or group address (I/G=1), and the second least significant bit of Octet 0 (the U/L bit) indicates universal (U/L=0) or local (U/L=1) administration of the address. A universally administered address is intended to be a globally unique address.

In an EUI created by extending an OUI, the OUI is the initial (most significant) three octets. In an EUI created by extending an OUI-36, the OUI-36 is the initial (most significant) four and a half octets.

Since OUI and OUI-36 assignments made by the IEEE RA have the X bit equal to 0, an EUI created as an extended identifier from an assigned OUI or OUI-36 has U/L=0 and, when used as a MAC address, is thus a universally administered address.

Since all OUI and OUI-36 assignments made by the IEEE RA have the M bit equal to 0, an EUI created as an extended identifier from an assigned OUI or OUI-36 has I/G=0 and, when used as a MAC address, is thus an individual address.

The assignee of an OUI or OUI-36 is exclusively authorized to assign group MAC addresses, with I/G=1, by extending a modified version of the assigned OUI or OUI-36 in which the M bit is set to 1. Such addresses are not EUIs and do not globally identify hardware instances, even though U/L=0.

### **Extended Local Identifier (ELI)**

An Extended Local Identifier (ELI) is created by concatenation from a CID, which comprises the initial three (most significant) octets. The ELI-48 is a 48-bit ELI and the ELI-64 is a 64-bit ELI.

Since CID assignments made by the IEEE RA have the X bit equal to 1, an ELI created as an extended identifier from an assigned CID has U/L=1 and is thus,

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when used as a MAC address, a local address. Local addresses are not globally unique, and a network administrator is responsible for assuring that any local addresses assigned are unique within the span of use. (Uniqueness of local addresses typically does not need to extend beyond a router.) IEEE Std 802 (beginning with the amendment IEEE Std 802c-2017) specifies the Structured Local Address Plan (SLAP), which describes the use of ELIs in one quadrant of local MAC address space, based on the specified values of the CID Y bit and Z bit. In other quadrants of local MAC address space, the SLAP describes the use of Standard Assigned Identifiers (SAIs) and Administratively Assigned Identifiers (AAIs) not based on a CID.

Since all CID assignments made by the IEEE RA have the M bit equal to 0, an ELI created as an extended identifier from an assigned CID has I/G=0 and is thus, when used as a MAC address, an individual address. The assignee of a CID may assign local group MAC addresses by extending a modified version of the assigned CID by setting the M bit to 1 (so that I/G=1). The resulting extended identifier is an ELI.

### IEEE RA assignment of identifiers

An assigned EUI block can be viewed as a sequence of numbers extended from a base number (e.g., OUI) by concatenation of an extension identifier. It can also be described as a contiguous range of EUI-48 or EUI-64.

EUI blocks are assigned by the IEEE RA in three different sizes. The MA-L assignment block provides both  $2^{24}$  EUI-48 identifiers and  $2^{40}$  EUI-64 identifiers. The MA-M assignment block provides both  $2^{20}$  EUI-48 identifiers and  $2^{36}$  EUI-64 identifiers. The MA-S assignment block provides both  $2^{12}$  EUI-48 identifiers and  $2^{28}$  EUI-64 identifiers.

The MA-L assignment includes the assignment of the OUI that is the base for the assigned EUI-48 and EUI-64 extended identifier blocks. An MA-L is equivalent to an OUI assignment made prior to January 1, 2014, which also included assignment of both an OUI and the associated blocks of EUI-48 and EUI-64 identifiers.

The MA-S assignment includes the assignment of the OUI-36 that is the base for the assigned EUI-48 and EUI-64 extended identifier blocks. The MA-S does not include assignment of a 24-bit OUI. The 24 initial bits of the assigned MA-S block is an OUI assigned to the IEEE RA.

NOTE – The MA-S assignment became available January 1, 2014. The MA-S assignment replaced both the Individual Address Block (IAB) and the OUI-36 assignments offered by the IEEE RA prior to January 1, 2014. The IAB came only with a block of 4096 EUI-48 identifiers and did not provide any other identifiers, e.g., EUI-64 identifiers; see the sub-section “IAB-Based Identifiers”

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later in this tutorial.

The MA-M does not include assignment of an OUI. The assignee of the MA-M may create an OUI-36 as the first 36 bits of an address in the MA-M assignment block. If the assignee of an MA-M needs a unique 24-bit organization identifier, a CID assignment is recommended. The first 24-bits of the assigned MA-M block are an OUI assigned to IEEE that will not be reassigned.

*NOTE* – The MA-M assignment became available January 1, 2014 in response to customer requests for an intermediate block of identifiers.

The CID assignment is of a single unique 24-bit identifier usable to identify a company, organization etc. The CID assignment does not include any EUI-48 or EUI-64 assignments, and a CID shall not be used to create an EUI-48 or EUI-64. A CID could be complementary to an MA-M or MA-S assignment for an entity seeking a unique 24-bit identifier, because those assignments do not include an OUI.

The OUI, OUI-36, CID, EUI-48 and EUI-64 assignments available from the IEEE RA are summarized in Table 5.

Table 5: EUI, OUI, and CID assignment summary

IEEE RA Assignment	Number of IEEE assigned bits	Block size of globally unique EUI-48 identifiers	Block size of globally unique EUI-64 identifiers	company or organization identifier included
MA-L (MAC Addresses – Large)	24	$2^{24}$ (16,777,216)	$2^{40}$ (1,099,511,627,776)	OUI (24-bit)
MA-M (MAC Addresses – Medium)	28	$2^{20}$ (1,048,576)	$2^{36}$ (68,719,476,736)	none
MA-S (MAC Addresses– Small)	36	$2^{12}$ (4096)	$2^{28}$ (268,435,456)	OUI-36 (36-bit)
CID (Company ID)	24	0 (zero)	0 (zero)	CID (24-bit)

The assignee of the IEEE identifier is responsible for administering the extension identifiers within its assigned block. The IEEE RA has no control over the assignments of the extension identifiers and assumes no liability for

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assignments of duplicate extension identifiers by an organization using an IEEE-assigned identifier (e.g., duplicate context dependent identifiers, EUI-48, or EUI-64 values).

The assignments of the IEEE-administered identifiers in Table 5 are typically public and available from the IEEE RA, so that an interested user can identify the registered owner of an EUI-48, EUI-64, OUI, OUI-36, or CID<sup>4</sup>. However, for assignees electing to use the private listing option, the IEEE assignment, but not identity of the assignee, is publicly available.

### EUI Structure and Representation

Table 6 illustrates the structure of the EUI-48 and its relationship to the assignments made by the IEEE RA.

Table 6: Structure of EUI-48

octet identifier	MSB							LSB
	0	1	2	3	4	5		
MA-L	24-bit OUI			24-bit extension				
MA-M	28-bit MA-M base				20-bit extension			
MA-S	36-bit OUI-36					12-bit extension		
example value (hex)	AC	DE	48	23	45	67		
example value (binary)	1010 : 1100	1101 : 1110	0100 : 1000	0010 : 0011	0100 : 0101	0110 : 0111		

An EUI-48 is a string of six octets, labeled in Table 6 from Octet 0 (initial and most significant) through Octet 5 (final and least significant). Table 6 includes, in the final two rows, an example EUI-48 with the base-16 form "ACDE48234567" and the hex representation "AC-DE-48-23-45-67". Note that an EUI-48 can be represented in the IEEE RA hexadecimal (hex) form with the octets separated by hyphens, or as a pure base-16 numerical representation

<sup>4</sup> The IEEE RA public listing <<https://regauth.standards.ieee.org/standards-ra-web/pub/view.html#registries>> provides separate databases for MA-L, MA-M, and MA-S. If the first 24 bits match an OUI assigned to the IEEE RA, then a search of the first 28 or 36 bits may reveal an MA-M or MA-S assignment. If the OUI-36 is not found in an MA-S search, then a search of the first 24 or 28 bits may reveal an MA-L or MA-M assignment from which the OUI-36 has been created from a member of the assigned block.

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without hyphens. It may also be represented as a binary number or sequence, as illustrated.

Table 6 illustrates examples of how EUI-48 might have arisen following: an MA-L assignment with the OUI AC-DE-48, and an entity assignment of the extension identifier of 23-45-67; an MA-M assignment with the base AC-DE-48-2, and an entity assignment of the extension identifier of 3-45-67; and an MA-S assignment with the OUI-36 AC-DE-48-23-4, and an entity assignment of the extension identifier of 5-67.

EUI-64 is represented similarly, as a string of eight octets, from Octet 0 (initial and most significant) through Octet 7 (final and least significant). This is shown in Table 7, using the example EUI-64 with the base-16 form "ACDE48234567019F" and the hex representation "AC-DE-48-23-45-67-01-9F".

Table 7: Structure of EUI-64

Note: Figure corrected, 2018-05-01.

octet identifier	MSB							LSB
	0	1	2	3	4	5	6	7
MA-L	24-bit OUI			40-bit extension				
MA-M	28-bit MA-M base			36-bit extension				
MA-S	36-bit OUI-36				28-bit extension			
example value (hex)	AC	DE	48	23	45	67	01	9F
example value (binary)	1010 : 1100	1101 : 1110	0100 : 1000	0010 : 0011	0100 : 0101	0110 : 0111	0000 : 0000	1001 : 1111

### EUI Bit Ordering

While the order of the EUI octets, and the bits within the octets, is specific and fixed, the sequence of their transmission can vary based on the protocol. Typically, octet-based transmissions transmit in ascending order of octet identifiers, beginning with octet 0. Some block codes encode multiple octets. Bit-serial encodings of data may differ in the ordering of bit transmissions within octets. Likewise, the order of address storage in memory can vary depending on the protocol. Further information on bit transmission order is available in relevant standards, such as IEEE Std 802.

Given the possible confusion of bit ordering and byte positioning, applications and protocols must unambiguously specify a mapping of the identifier value (expressed as hexadecimal digits) to the applicable register or byte and bit sequence. To ensure clarity, each mapping should be self-contained. If it is

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deemed necessary to cross-reference other documents, the specific document and page number shall be cross-referenced, so that unfamiliar readers can easily find the source.

To avoid changes in existing standards, a working group may alternatively provide tutorials on any uses of identifiers in its standards, to be posted on the IEEE RA web site.

If a standard, or its cross-referenced portions of other standards, does not conform to these documentation policies, the IEEE Registration Authority Committee (RAC) can recommend the standard not be approved.

### Unassigned and NULL EUI values

Many applications have found it useful to define a distinct null identifier, most often indicating the absence of a valid EUI-48 or EUI-64 value. As an example, a null value might be the power-on state for an integrated circuit register, until the hardware or firmware initializes the register with a valid EUI. Similarly, where the EUI of another device or object is placed in a protocol field, a null value may be used until the valid EUI value to be placed in the protocol field is learned. A management information base parameter also may face a similar initial-value issue making use of a null value convenient.

The all-zeros EUI-48 value (00-00-00-00-00-00) and EUI-64 value (00-00-00-00-00-00-00-00), though assigned to an organization, have not been and will not be used by that assignee as an EUI. (They can be considered as assigned to the IEEE Registration Authority.) The all-ones 48-bit value (FF-FF-FF-FF-FF-FF) and 64-bit value (FF-FF-FF-FF-FF-FF-FF-FF) are IEEE 802 multicast (group) MAC addresses indicating all stations on a network. These all-ones values are not valid EUIs.

The recommended null values are FF-FF-FF-FF-FF-FF and FF-FF-FF-FF-FF-FF-FF-FF, as defaults for unknown EUI-48 and EUI-64 values, respectively. Values based on a zero-valued OUI, such as 00-00-00-00-00-00 and 00-00-00-00-00-00-00-00, shall not be used as identifiers.

### Appropriate EUI Use

EUIs are intended to be used in applications that require fixed-size globally unique identifiers.

Except in certain cases, such as protocol identifiers, an assignee associates an EUI-48 or EUI-64 with a single identifiable object (e.g., a network interface). Depending on the functions supported by a device, it may use more than one identifier. For example, a smart phone could have an EUI-48 used as the 802.11/Wi-Fi® MAC address and a second identifier for the Bluetooth® interface. An Ethernet connected device could have an EUI-48 MAC address

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and an EUI-64 that uniquely identifies an 802.1AS clock (i.e., a “clockIdentity”.)

The EUI-64 is used instead of EUI-48 to avoid excess consumption of OUI values within high-volume, particularly non-networking, applications. Given the minimal probability of consuming all EUI-64 identifiers, the IEEE RA places minimal restrictions on their use within standards. Unless mandated by backward-compatibility constraints, the use of EUI-64 is preferred to the use of EUI-48. However, for backward compatibility, this transition may be difficult for some IEEE 802-related applications (e.g., new networks that need to bridge to 48-bit IEEE 802 networks). Therefore, selective use of 48-bit identifiers within 802-related systems will be considered by the IEEE Registration Authority Committee. See “Maintaining Longevity of EUI-48 and EUI-64” below for further details.

The terms EUI-48 and EUI-64 are trademarked by IEEE. Organizations are allowed limited use of these terms for commercial purposes. Where such use is an identification of features or capabilities specified within a standard or for claiming compliance to an IEEE standard, use without explicit approval of IEEE is acceptable, but other use of the terms must be reviewed and approved by the IEEE RAC.

When an EUI is used within the context of an IEEE standard or draft standard, the draft shall be reviewed by the IEEE RAC for correctness and clarity. When an EUI is referenced within non-IEEE standards, the standard developers should contact the IEEE RAC for review of proper usage.

### **Maintaining Longevity of EUI-48 and EUI-64**

The total number of EUI-48 identifiers available, while large, is NOT inexhaustible. The IEEE RAC has the duty to promote the continued availability of the EUI-48 capability in conjunction with IEEE standards and non-IEEE standards, for the benefit of the world-wide community using those standards.

Initially, EUI-48 identifiers were intended only to identify items of real physical equipment, parts of such equipment, or functions that apply to many instances of physical equipment.

The use of 48-bit identifiers was later extended so that they may serve as protocol identifiers. With this use, they identify protocol designs and design revisions of protocols operating between instances of physical equipment. Compared to quantity of items of physical equipment, far fewer identifiers for such protocols are expected to be needed.

With the exception of such protocol identifiers, EUI-48 identifiers are still intended to identify items of real physical equipment or parts of such

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equipment, such as separable subsystems or individually addressable network ports. The expected use should not exceed one EUI-48 identifier per hardware subsystem, or at most a very low number of EUI-48 identifiers per physical instance of such equipment (e.g., groups of ports as in IEEE Std 802.1AX, for link aggregation). 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.

Any specifications in standards, or assignee implementations or assignee administration of a EUI block, that call for subdivision of the available number space, for block allocation to product types or block allocation to physical equipment without an identifiable physical instance per EUI-48 identifier, or for encoding functional capabilities within significant bits or bit patterns of the identifier, have the potential to rapidly exhaust the address space. To reduce the prospect of exhaustion, new applications and proposed extensions to current applications with significant volume expectations are **STRONGLY** encouraged to make use of EUI-64, rather than EUI-48, to identify hardware instances. New applications specified in standards that require an address format matching the existing base of EUI-48 equipment will be reviewed by the IEEE RAC and such exceptions will only be approved on a case-by-case basis. Non-standard uses of EUI-48 are not supported.

The IEEE RAC solicits any information about threats to the viability of the unique EUI-48/EUI-64 address space, whether an IEEE proposed standard or another standard or specification. Information should be sent to the IEEE RAC administrator ([ieee-registration-authority@ieee.org](mailto:ieee-registration-authority@ieee.org)). Furthermore, in carrying out this duty to preserve the longevity of these identifier capabilities, the IEEE RAC will act, via liaison or direct coordination, to prevent potentially abusive uses for the consumption of EUI-48s.

When IEEE 802 began its work in 1980, the target lifetime of EUI-48 identifiers was 100 years. More than a third of the way through that century of lifetime, the use of EUI-48 identifiers continues to grow, with no indication that EUI-48 addresses will be obsolete by 2080. Consequently the IEEE RAC regards the consistent enforcement of these restrictions as a fundamental and realistic basis for ensuring longevity of the EUI-48 identifier.

If an entity, whether an IEEE RA customer or not, has either intentionally or accidentally misused an IEEE RA assignment such that EUI-48/EUI-64 addresses, or any other identifiers that the entity creates from its RA assignment, are allocated outside its assignment(s), then the entity is in violation of IEEE RAC policies. In such cases, the IEEE RAC may recommend the IEEE RA collect additional fees from the entity to remedy any potential duplication and/or discourage future misuse.

### Non-Overlapping Assignments

Assignees are encouraged to assign only one form of EUI-48 or EUI-64 identifier, regardless of application. In other words, the organization is encouraged to not assign the same identifier to multiple organizations for different end-application uses. The intent of this recommendation is to reduce possible errors introduced by the complexities of managing multiple context-dependent address spaces within each organization.

For example, EUI-48 values that specify I/O driver software interfaces, language codes, and hardware model numbers should never overlap. Similarly, EUI-64 values that specify I/O driver software interfaces, language codes, hardware model numbers, and hardware instances should never overlap. This no-overlap strategy is expected to reduce unintentional duplication of identifier values, by elimination of subjective application-class judgments, although a few more identifier values may be consumed.

### IEEE RA Policies to Reduce the Volume of Unused EUI-48s

An MA-L assignment includes more than 16 million ( $2^{24}$ ) unique EUI-48 values. To reduce the occurrences of unused EUI-48s (e.g., when the assignee needs far less than 16 million EUI-48s), the IEEE RAC instituted the following policies for assigning MA-L, MA-M, MA-S, and CID identifiers when the CID was first introduced:

- 1) First-time customers (i.e., assignees) cannot purchase the MA-L. A first-time customer that needs a 24 bit company/organization identifier can purchase a CID, and a first-time customer that needs EUI-48s or EUI-64s (or deprecated identifiers) can purchase an MA-M or MA-S, depending on how many of each particular identifier the customer needs. Exception to this policy must be reviewed by the IEEE RAC.
- 2) Repeat customers (i.e., customers who have previously purchased an MA-L, MA-M, MA-S, and/or CID) can purchase any of the identifier block sizes, subject to the following restrictions:
  - a) The IEEE Registration Authority will accept an additional assignment application upon the certification that at least 95% of the current MA-L or MA-M allocation of EUI-48s is used. The same applies to OUI assignments issued prior to January 2014. An additional assignment may be issued when a significant portion of the existing assignment of EUI-48s has been exhausted. Customers must agree to not produce products using the new assignment of EUI-48s until the previous assignment is fully exhausted. This applies to all registry assignments.
  - b) A customer that has either an MA-L (or, prior to January 1, 2014, an

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OUI) or CID assignment should not need to purchase a new CID for company identification but is eligible to purchase a new CID for other uses, for example, when a current CID assignment provides insufficient EUI address space.

An IEEE-administered organizational identifier identifies the organization that administers the concatenated extension identifiers to create, for example, EUIs. The IEEE-administered identifier should not be used, in isolation, to identify a division or similar portion of a company or organization. When an assignee feels it necessary to identify such an internal group, the EUI-48 or EUI-64 identifier can be used. (An assignee administration practice that uses some of the extension bits to identify a division or product does not exempt the assignee from the requirement to use the vast majority of the EUI-48 values as described above.) Groups within a standards development organization can similarly be identified by distinct EUI-48 (or EUI-64) identifiers administered by their sponsoring body.

### Mapping an EUI-48 to an EUI-64

Mapping an EUI-48 to an EUI-64 is deprecated. The mapping is described here for historical reasons.

Mapping an EUI-48 assigned with an MA-S/OUI-36 or MA-M assignment to an EUI-64 potentially creates a duplicate of an EUI-64 assigned with a different MA-S/OUI-36 or MA-M. The IEEE RA has taken appropriate actions to mitigate creation of duplicates based on this mapping but, to protect the integrity of EUI-64 identifiers, this mapping is deprecated.

Some standards have described how an EUI-48 value could be mapped to an EUI-64, as follows: Let the six octets of the EUI-48 be labeled `eui48[0]` through `eui48[5]`. Let the eight octets of the mapped EUI-64 be labeled `eui64[0]` through `eui64[7]`. The following mapping has been described:

- `eui64[0] = eui48[0]`
- `eui64[1] = eui48[1]`
- `eui64[2] = eui48[2]`
- `eui64[3] = FFhex`
- `eui64[4] = FEhex` or `eui64[4] = FFhex`
- `eui64[5] = eui48[3]`
- `eui64[6] = eui48[4]`
- `eui64[7] = eui48[5]`

In other words, the EUI-64 value was generated by inserting either the value FF-FEhex or the value FF-FFhex in between `eui48[2]` and `eui48[3]`.

### Other worldwide identifiers based on EUI

Some formats of World Wide Names (WWN) are derived from an EUI-48 or EUI-64. WWNs are used as disk and endpoint addresses in SCSI and associated

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protocols. Please refer to latest INCITS SATA and SAS standards for additional details.

IPv6 addressing derived from EUI-64 is defined in IETF RFC 4291, Appendix A. Please see also IETF RFCs 2460, 5952, and 6052.

UUID addressing derived from EUI-64 addresses and OUIs is defined in IETF RFC 4122 in ITU-T X.667.

### **Context dependent identifiers**

Just as the OUI is extended to create EUI-48 and EUI-64 identifiers, or a CID can be extended to create a locally administered MAC address, other extended identifiers can be created from an OUI or CID assignment. Such extended identifiers, referred to as context dependent identifiers, are not necessarily globally unique but are intended to only be unique within a well specified context.

A Context Dependent Identifier (CDI) is an extended identifier based on either an OUI, CID, or OUI-36 and typically specified within a standard with additional specification to allow unambiguous interpretation of the identifier and parsing of other data. Some examples include (but are not limited to):

- Defining all fields of the context dependent identifier within a standard. For example, using an OUI or CID to identify a manufacturer of hardware with additional fields identifying the model and revision of the hardware. (The OUI or CID owner typically assigns the values for the additional fields within bounds specified by the standard.) Such an identifier, if properly defined, is unique within the context of the standard.
- Defining vendor-specific extensions to management information within a standard but allowing the assignee of the unique identifier to specify the additional fields. This extended identifier would be unique within the context of the defined management information base.
- A vendor-specific protocol could be identified with an OUI/CID, and a standard defined fixed field to allow identification of multiple protocols from the same vendor; or with the OUI/CID indicating which set of rules to parse the data following the OUI/CID.
- The legacy definition of CDI-32 and CDI-40 (see "Deprecated and Obsolete Identifiers").

### **Restrictions on the Use of Context Dependent Identifiers**

Except where compatibility with legacy definitions of 22-bit company identification is justifiable, the OUI is used as a 24-bit field when creating context dependent identifiers. A CID should serve as an effective alternative to the OUI in such cases. Specifications for context dependent identifiers should allow use of either OUI or CID as the base for the context dependent

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identifier.

The following cautions are provided for those specifying context dependent identifiers:

- If the context within which the assignment of the extension identifier is required to be unique is not accurately defined, then there is the danger of inadvertent re-use of an existing identifier assignment for a different purpose, leading to ambiguity in the use of the assigned values;
- If the chosen size of the extension identifier is small relative to the actual number of identifier values that will need to be assigned under a single OUI/CID, then the result could be an unacceptable rate of consumption of OUI/CID values, and potential difficulty in the owner of an OUI meeting the Registration Authority's requirement that 95% of the block assignment represented by their existing OUI be consumed before making use of a further assignment.

Consequently, the use of context-dependent identifiers is acceptable, subject to the use meeting all of the following requirements:

- The context within which the context-dependent identifier is used, and within which its identifier values are required to be unique is clearly defined in the relevant standard.
- The size of the chosen extension identifier is large enough to accommodate all conceivable requirements for the allocation of distinct values under a single OUI within the defined context.
- The IEEE RAC has approved the identifier and the definition of the context within which it will be used.
- Draft standards or working group materials that describe a proposed context-dependent identifier and its proposed application should be submitted to the IEEE RAC.

### Deprecated and Obsolete Identifiers

There is no standard definition of the term 'deprecated' across IEEE. When used by the IEEE RA or IEEE RAC, the term 'deprecated' means that the item it is describing (e.g., identifier, mapping, requirement, recommendation, process, etc.) shall not be used in any new applications. Legacy uses may be preserved in a revision or amendment if justified (e.g., so that an amendment does not introduce inconsistency into the standard). When terminology evolves, updates to use the current terms and remove deprecated terms should be done as soon as practical. In addition, new equipment and new designs are not to use the deprecated item, except to remain compliant to the relevant standard. Existing equipment and deployed equipment need not be modified to not use the deprecated item.

## Guidelines for Use of EUI, OUI, and CID

Several identifiers and terms used in the past, including some that were created from IEEE-administered identifiers (i.e., created by organizations that were assigned IEEE-administered identifiers), are now deprecated or obsolete. These identifiers and terms include the Individual Address Block (IAB), the 22-bit OUI-based identifiers, the MAC-48 identifier, and the EUI-60. These identifiers are briefly described in the following sub-sections.

### IAB-Based Identifiers

The 36-bit IAB identifier is no longer assigned. An IAB assignment was a block of 4096 MAC-48 addresses (now called EUI-48). The base 24-bit OUI is assigned to the IEEE RA and an additional 12-bit extension assigned by the IEEE RA produced the first 36 bits for the block of addresses. The 4096 EUI-48 identifiers were then created by the assignee by a further 12-bits concatenated with the 36-bit IAB base number.

The IAB can be used only for the purpose of assigning EUI-48 identifiers; any other identifiers that might be created by the use of the 24-bit OUI value used to create the IAB remain the property of the IEEE RA. In addition, the IAB cannot be used to create any other identifiers using the 36 bits assigned to the assignee (e.g., the assignee cannot create an EUI-64 by appending 28 bits to the IAB identifier it has been assigned).

While the IEEE RA did not guarantee that the 36-bit IAB identifier would always be created from the same OUI, all IAB assignments were in fact created from two particular OUIs: 00-50-C2hex and 40-D8-55hex. The former was used until all the IABs based on it were assigned, after which the latter was used.

The EUI-48 usage of an IAB and MA-S are the same, so an organization that was assigned an IAB may continue to use it as originally intended. Any new requests made to the IEEE RA for an IAB will be fulfilled by assigning an MA-S.

Going forward, the existing IAB public listing will be maintained as a historical registry. Since no new IABs will be assigned, there will be no additions to the IAB registry.

### 22-Bit OUI-Based Identifiers

Though the OUI has always been specified as a 24-bit value, a variety of alternative, context-dependent identifiers were specified in the past. Some standards specify use of only 22-bits of the OUI (dropping the M and X bits). Such uses are deprecated. All new specifications for use of an OUI, except for networking addressing, shall use all 24-bits of the OUI as assigned by the IEEE RA. This allows use of either an OUI or CID.

### MAC-48

The term MAC-48 is now obsolete. The MAC-48 was similar to the EUI-48, i.e., it was a concatenation of a 24-bit OUI assigned by the IEEE RA and a 24-bit extension identifier assigned by the organization with that OUI assignment. However, it was used to address hardware interfaces within existing 802-based networking applications. The term EUI-48 was historically used to identify a design instance, as opposed to a hardware interface; examples include software interface standards (such as VGA), the model number for a product, and the form/function of vendor-specific content. The subtle difference between MAC-48 and EUI-48 was not well understood, so the term EUI-48 is now used for both uses, and the term MAC-48 identifier is now obsolete. (The IEEE RAC is not aware of any cases, but if MAC-48 is used as the name for any 48-bit MAC address, then EUI-48 is not the appropriate replacement term for MAC-48, as EUI-48 only refers to individual, universally/globally unique network addresses.)

### EUI-60

The EUI-60 should not be used in future applications. There is no plan to eliminate the use of these EUI-60 values in the foreseeable future. EUI-64 (as opposed to EUI-60) identifiers should be used in future applications, future standards, and revisions and amendments of existing standards requiring the use of unique per-hardware instance identifiers.

### CDI-32 and CDI-40

CDI-32 and CDI-40 were historically recommended as context dependent identifiers.

CDI-32 was, historically, a concatenation of an OUI value assigned by the IEEE RA and an 8-bit extension identifier assigned by the organization with that OUI assignment.

CDI-40 was, historically, a concatenation of an OUI value assigned by the IEEE RA and a 16-bit extension identifier assigned by the organization with that OUI assignment.