



IEEE Standard for Local and metropolitan area networks— Secure Device Identity

IEEE Computer Society

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IEEE Standard for Local and metropolitan area networks— Secure Device Identity

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of the
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Abstract: A secure device identifier (DevID) is cryptographically bound to a device and supports authentication of the device's identity. Locally significant identities can be securely associated with an initial manufacturer-provisioned DevID and used in provisioning and authentication protocols to allow a network administrator to establish the trustworthiness of a device and select appropriate policies for transmission and reception of data and control protocols to and from the device.

Keywords: access control, authentication, authorization, certificate, LANs, local area networks, MAC security, MANs, metropolitan area networks, PKI, port-based network access control, secure association, secure device identifier, security, X.509

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Introduction

This introduction is not part of IEEE Std 802.1AR-2009, IEEE Standard for Local and metropolitan area networks—Secure Device Identity.

A secure device identifier (DevID) is a cryptographic identity bound to a device used for assertion of the device's identity. IEEE Std 802.1AR specifies

- globally unique per-device identifiers and the management and cryptographic binding of a device to its identifiers,
- the relationship between an initially installed identity and subsequent locally significant identities, and
- interfaces and methods for use of DevIDs with existing and new provisioning and authentication protocols.

IEEE Std 802.1AR can be used in conjunction with IEEE Std 802.1X™ [B2] and other IEEE and industry standards that require a secure identifier or credential as part of authentication and provisioning processes that establish trust in a device.¹

This is the first edition of IEEE Std 802.1AR.

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1. Overview

IEEE 802[®] Local Area Networks (LANs) are often deployed in networks that provide publicly accessible service access or that cannot be completely physically secured. The protocols that configure, manage, and regulate access to these networks and network-based services and applications typically run over the networks themselves. Secure and predictable operation of such networks depends on authenticating each device attached to and participating in the network, so that the degree of trust and authorization to be accorded to that device by its communicating peers can be determined.

Authentication of a human user, through a credential known to or possessed by that user, is often used to authenticate users of devices such as laptop personal computers. However many of the devices that compose a network are designed for unattended autonomous operation and might not support user authentication. These include the routers and bridges that interconnect and provide access to the LANs. Further, the previously common assumption that network access controls were to provide protection of the network against abuse through unauthenticated and unauthorized access, while offering no protection to the accessing devices, is now known not only to expose those devices but also the network itself. Failure to provide devices that access the network with the mutual guarantee that they are connected to legitimate network access points allows malicious devices to interpose themselves between the network and its authenticated and authorized users, and effectively make use of the credentials of the latter. For these reasons a secure device identifier, i.e., one that embodies an authentication credential that cannot be easily removed or copied for use in a device under the control of someone who wishes to gain unauthorized access to or attack the operation of a network, is highly desirable.

Protocols for configuring, managing and regulating access to a network depend on the existence of a device identifier or human authentication of initial access to associate a device with an authentication credential.

This results in a “chicken-and-egg” scenario, wherein these credentials often must be installed during an expensive “pre-provisioning” process before actual deployment. Even when device credentials are deployed in-place, the process is often interactive, involving a physically secured connection to the device being deployed and a knowledgeable system administrator.

Secure Device Identifiers (DevIDs) are designed to be used as interoperable secure device authentication credentials with Extensible Authentication Protocol (EAP) and other industry standard authentication and provisioning protocols. A standardized device identity facilitates interoperable secure device authentication that helps simplify and standardize secure deployment and management of devices. This standard will be of benefit to manufacturers of conformant LAN equipment, their customers, and users of LANs or LAN services that are based on such equipment.

A device with DevID capability incorporates a globally unique manufacturer provided Initial Device Identifier (IDevID), stored in a way that protects it from modification. The device may support the creation of Locally Significant Device Identifiers (LDevIDs) by a network administrator. Each LDevID is bound to the device in a way that makes it infeasible for it to be forged or transferred to a device with a different IDevID without knowledge of the private key used to effect the cryptographic binding. LDevIDs can incorporate, and fully protect, additional information specified by the network administrator to support local authorization conventions. LDevIDs may also be used as the sole identifier (by disabling the IDevID) to assure the privacy of the user of a DevID and the equipment in which it is installed.

1.1 Scope

This standard specifies unique per-device identifiers (DevID) and the management and cryptographic binding of a device to its identifiers, the relationship between an initially installed identity and subsequent locally significant identities, and interfaces and methods for use of DevIDs with existing and new provisioning and authentication protocols.

1.2 Purpose

This standard defines a standard identifier for IEEE 802 devices that is cryptographically bound to that device, and defines a standard mechanism to authenticate a device’s identity. A verifiable unique device identity allows establishment of the trustworthiness of devices. This facilitates secure device provisioning.

1.3 Relationship to other standards

The present work has been undertaken to provide an identifier that is generally useful across IEEE 802 networks. It draws on and is informed by other standards that have been developed elsewhere for different purposes. Where possible, this work attempts compatibility with the following standards:

- a) Trusted Platform Module (TPM)
- b) Worldwide Interoperability for Microwave Access (WiMAX)
- c) Extensible Authentication Protocol-Transport Layer Security (EAP-TLS)

For other standards that have influenced the development of this standard or are of general interest see the bibliography (Annex D).

2. Normative references

The following referenced documents are indispensable for the application of this standard (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

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²ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

³IETF RFCs are available from the Internet Engineering Task Force Web site at <http://www.ietf.org/rfc.html>.

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IETF RFC 5480, Elliptic Curve Cryptography Subject Public Key Information, Turner, S., Brown, D., Yiu, K., Housley, R., Polk, T., March 2009

ISO/IEC 15802-1:1995, Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Common specifications—Part 1: Medium Access Control (MAC) service definition.⁴

NIST FIPS 140-2, Annex C: Approved Random Number Generators.⁵

NIST FIPS 180-3, Secure Hash Standard (SHS), October 2008.

NIST FIPS 186-3, Digital Signature Standards (DSS), June 2009.

Standards for Efficient Cryptography (SEC), “SEC 1: Elliptic Curve Cryptography,” Certicom Research, 2000.⁶

⁴ISO/IEC publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iso.ch/>). ISO/IEC publications are also available in the United States from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (<http://global.ihs.com/>). Electronic copies are available in the United States from the American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

⁵NIST publications are available from the National Institute of Standards and Technology, NIST Public Inquiries, NIST, 100 Bureau Drive, Stop 3460, Gaithersburg, MD, 20899-3460, USA (www.nist.gov).

⁶This document is available at http://www.secg.org/collateral/sec1_final.pdf.

3. Definitions

For the purposes of this document, the following terms and definitions apply. *The IEEE Standards Dictionary: Glossary of Terms & Definitions* should be referenced for terms not defined in this clause.⁷

aggregate device: A device containing multiple logical or physical devices.

authentication: The process of verifying an identity claimed by or for a system entity. Defined in RFC 4949.⁸

authentication exchange: The two-party conversation between systems performing an authentication process.

NOTE—Examples of authentication exchange methods are Extensible Authentication Protocol (EAP) and Simple Authentication and Security Layer (SASL).⁹

authentication process: The cryptographic operations and supporting data frames that perform the actual authentication.

Authenticator: An entity that facilitates authentication of other entities attached to the same LAN.

binding: *See:* **cryptographic binding**.

certificate revocation list (CRL): A signed list of revoked certificates. Defined in RFC 5280.

certificate signing request (CSR): A signed message from the device to the Certification Authority (CA) requesting a certificate be issued. This is a variant of the RFC 2986 defined `CertificateRequest` with additional specifications to enable the use of Elliptic Curve Cryptography (ECC).

cipher suite: A set of one or more algorithms, designed to provide any number of the following: data confidentiality, data authenticity, data integrity, replay protection.

client: The protocol entity that makes use of a service.

credential: A data object that provides authentication information such as a public key along with other identity fields. The entity identified by a credential normally possesses a secret or private key that can be used to prove its identity.

cryptographic binding: A data object constructed using cryptographic operations to combine a secret with other arbitrary data objects such that it may be proven that the result could only be created by an entity having knowledge of the secret.

cryptographic key: A parameter that determines the operation of a cryptographic function such as the following:

- a) The transformation from plain text to cipher text and vice versa
- b) Synchronized generation of keying material
- c) Digital signature computation or validation¹⁰

⁷The *IEEE Standards Dictionary: Glossary of Terms & Definitions* is available at <http://shop.ieee.org/>.

⁸Information on references can be found in Clause 2.

⁹Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

¹⁰This and other definitions in this clause have been drawn from ASC X9 TR1, Technical Report for ABA ASC/X9 Standards Definitions, Acronyms, and Symbols, 2002.

device: A device is any entity that has a single IDevID credential.

IEEE 802 Local Area Network (LAN): IEEE 802 LANs are LAN technologies that provide a MAC Service equivalent to the MAC Service defined in ISO/IEC 15802-1:1995. IEEE 802 LANs include IEEE 802.3™ (CSMA/CD), IEEE 802.11™ (wireless), and IEEE 802.17™ (resilient packet ring).

NOTE—In this standard, also referred to simply as *LANs*.

Initial Secure Device Identifier (IDevID): The Secure Device Identifier installed on the device by the manufacturer.

key: *See:* cryptographic key.

Locally Significant Secure Device Identifiers (LDevIDs): A Secure Device Identifier credential that is unique in the local administrative domain in which the device is used.

Secure Device Identifier (DevID): A device identifier that is cryptographically bound to the device and is composed of the Secure Device Identifier Secret and the Secure Device Identifier Credential.

Secure Device Identifier Credential (DevID Credential), Secure Device Identifier Certificate (DevID Certificate): Synonym for a data object constructed using cryptographic operations to bind the DevID Name and other data to the cryptographic keying material possessed by the device.

Secure Device Identifier Module (DevID Module): A logical security component that will securely store and operate on one or more DevID Secret(s) and associated DevID Credentials.

Secure Device Identifier Root Credential Store: The database of root credentials for IDevID and LDevID credentials that are stored and used by a DevID compliant solution. This is equivalent to the common Web browser root store and may be shipped with the solution.

Secure Device Identifier Secret (DevID Secret): The private key portion of a public-private key pair bound to a DevID Credential.

zeroization: A method of erasing electronically stored data, cryptographic keys, and critical stored parameters by altering or deleting the contents of the data storage to prevent recovery of the data.

NOTE—Adapted from NIST Special Publication 800-57 [B32].¹¹

¹¹The numbers in brackets correspond to those of the bibliography in Annex D.

4. Acronyms and abbreviations

CA Certification Authority

NOTE—CA is also an abbreviation for secure Connectivity Association in IEEE Std 802.1AE™ and IEEE Std 802.1X™.

CPS Certification Practices Statement

CRL Certificate Revocation List

CSR Certificate Signing Request

EAP Extensible Authentication Protocol

EAP-TLS EAP Transport Layer Security

EC Elliptic Curve

ECC Elliptic Curve Cryptography

ECDSA Elliptic Curve Digital Signature Algorithm

FIPS Federal Information Processing Standard

IP Internet Protocol

LAN IEEE 802 Local Area Network

LMI Layer Management Interface

MAC Media Access Control

MIB Management Information Base

NIST National Institute of Standards and Technology

PICS Protocol Implementation Conformance Statement

PKCS Public-Key Cryptography Standards

RADIUS Remote Authentication Dial In User Service

RFC IETF Request for Comments

RNG random number generator

RSA Ron Rivest, Adi Shamir, and Leonard Adleman cryptography algorithm

SASL Simple Authentication and Security Layer

SHA Secure Hash Algorithm

SNMP Simple Network Management Protocol

SMI Structure of Management Information

TLS Transport Layer Security

TPM Trusted Platform Module

WiMAX Worldwide Interoperability for Microwave Access

5. Conformance

A claim of conformance to this standard is a claim that the behavior of an implementation of a Secure Device Identifier (IDeVID and LDeVID) meets the requirements of this standard as they apply to the format of the identifier, secure storage of it, and management of the identifier. Example uses of the DevID are provided but are not limited to the discussions in this standard.

Conformance to this standard does not ensure that a system implementing the standard is secure, nor does it ensure that the operation of protocols relying upon capabilities from this standard are immune to breaches by an attacker.

5.1 Requirements terminology

For consistency with existing IEEE standards, requirements placed upon conformant implementations of this standard are expressed using the following terminology:

- a) *shall* is used for mandatory requirements
- b) *may* is used to describe implementation or administrative choices (may means is permitted to, and hence, may and may not mean precisely the same thing)
- c) *should* is used for recommended choices (the behaviors described by should and should not are both permissible but not equally desirable choices)

The PICS proforma (see Annex A) reflects the occurrences of the words shall, may, and should within the standard.

The standard avoids needless repetition and apparent duplication of its formal requirements by using *is*, *is not*, *are*, and *are not* for definitions and the logical consequences of conformant behavior. Behavior that is permitted but is neither always required nor directly controlled by an implementer or administrator, or whose conformance requirement is detailed elsewhere, is described by *can*. Behavior that never occurs in a conformant implementation or system of conformant implementations is described by *can not*. The word *allow* is used as a replacement for the cliché “support the ability to...,” and the word *capability* means “is configurable such that...”

5.2 Protocol Implementation Conformance Statement

The supplier of an implementation that is claimed to conform to this standard shall complete a copy of the PICS proforma provided in Annex A and shall provide the information necessary to identify both the supplier and the implementation.

5.3 Required capabilities

A device for which conformance to this standard is claimed shall:

- a) Contain an IDeVID as specified in 6.2.1 (DevID credentials).
- b) Contain the credential chain as specified in 6.2.1 (DevID credentials).
- c) Support an RSA or ECDSA key as specified in 6.2.2 (Asymmetric cryptography).
- d) Generate random numbers as specified in 6.2.4 (Random number generator).
- e) Store an IDeVID secret as specified in 6.2.5 (Storage).
- f) Support the mandatory operations as specified in 6.3 (DevID Service Interface).
- g) Support the DevID credential format as specified in Clause 7 (DevID Credential details).

A device supporting Simple Network Management Protocol (SNMP) to manage the capabilities of DevIDs for which conformance to this standard is claimed shall:

- h) Restrict access to SNMP version 3 and higher, and only in privacy/authentication mode as specified in 6.3.12 (LDevID Credential insert).
- i) Implement the MIB Management Interface as specified in 6.4 (DevID Management Interface).

5.4 Optional capabilities

A device for which conformance to this standard is claimed may:

- a) Support LDevID credentials as specified in 6.2 (Components of a DevID module).
- b) Store DevID secrets externally to the DevID module as specified in 6.2.5 (Storage).
- c) Support the optional operations specified in 6.3 (DevID Service Interface).
- d) Share an LDevID key pair among multiple LDevID credentials as specified in 6.3.12 (LDevID Credential insert).
- e) Externally generate the IDevID secret as specified in 6.5.1 (Creation of DevID secret).
- f) Share the IDevID secret with LDevID credentials as specified in 6.5.1 (Creation of DevID secret).

5.5 Recommended capabilities

A device for which conformance to this standard is claimed should:

- a) Include Public Key Infrastructure (PKI) hierarchy root credentials in an easily discovered location as specified in 6.2.1 (DevID credentials).
- b) Support at least one LDevID credential as specified in 6.2.1 (DevID credentials).
- c) Encrypt externally stored secrets as specified in 6.2.5 (Storage).
- d) Support the recommended operations as specified in 6.3 (DevID Service Interface).
- e) Confirm that inserted LDevID credentials match this standards credential profile for LDevID credentials 6.3.12 (LDevID Credential insert).
- f) Publish the Certification Authority (CA) Certification Practices Statement (CPS) in the PICS as specified in 6.5.1 (Creation of DevID secret).
- g) Generate an independent LDevID secret as specified in 6.5.1 (Creation of DevID secret).
- h) Generate IDevID secret internally as specified in 6.5.1 (Creation of DevID secret).
- i) Report key generation mechanism in CPS as specified in 6.5.1 (Creation of DevID secret).
- j) Document key exposure plans in their PICS as specified in 6.6.1 (Mitigating risks of key exposure).
- k) Support identity hiding as specified in 6.6.3 (Identity Hiding).

The supplier for a device for which conformance to this standard is claimed should:

- l) Have a unique issuer name in the IDevID as specified in 7.2.4 (issuer).

6. Secure Device Identifier Module

This clause describes the logical components of the DevID Module. It provides the necessary context for understanding the security requirements (and acceptable practical limitations on those requirements) for the creation, use, maintenance, and deletion of DevID credentials. An overview of DevID credentials is provided although the details of DevID fields are specified in Clause 7 (DevID Credential details).

Informative use cases are provided in Annex C as examples.

6.1 What is a device?

A device is any entity in an IEEE 802 LAN that seeks to obtain services from the network or provide services on the network. A device is defined by having a single IDevID credential.

Multiple logical or physical devices may be contained within an aggregate device. Each of these logical or physical devices will have its own unique DevID. The DevID used to identify the aggregate device may depend on the context under which the identification of the aggregate device is done. The selection of a DevID based on this context is beyond the scope of this document. Service interfaces defined in 6.3 do not refer to aggregate devices.

The DevID module is a logical security component that stores and operates on the DevID secrets and associated DevID credentials. The PICS shall describe the device the DevID module is identifying.

6.2 Components of a DevID module

The components of a DevID module are shown in Figure 6-1. Implementations may provide additional functionalities. The DevID credential and DevID secret are used by the DevID module to prove the identity of the device. It is imperative that the DevID secret is securely protected from access by any other entity. The DevID credential is publicly available to any entity that wishes to verify the identity of a device.

6.2.1 DevID credentials

The DevID module shall include the IDevID and zero or more LDevIDs. At least one LDevID credential should be supported.

The DevID module shall include the entire credential chain up to the root credential and should include the root credential. For a shallow hierarchy this requirement could be met with only the IDevID credential on the device. The root certificates should be shipped along with the device or made available by the solution manufacturer in a reasonably discoverable fashion such as on the manufacturer's Web site.

The DevID credential format shall be as described in Clause 7 (DevID Credential details).

DevIDs have to be explicitly created. IDevIDs are normally created during manufacturing or initial provisioning, and can be generated internally in the DevID module or can be created externally and subsequently transferred to secure storage within the DevID module. LDevIDs can be created at any time, in accordance with local policies, and likewise can be created internally in the DevID module, or can be created externally and transferred to the DevID module.

Following creation, DevIDs enter their active use lifetime, during which they can be used and maintained in accordance with the administrative policies of the network and device owners possessing them. IDevIDs remain in their active use state until the effective lifetime ends or the IDevID is disabled. LDevIDs can be managed by the operations detailed in 6.3 (DevID Service Interface).

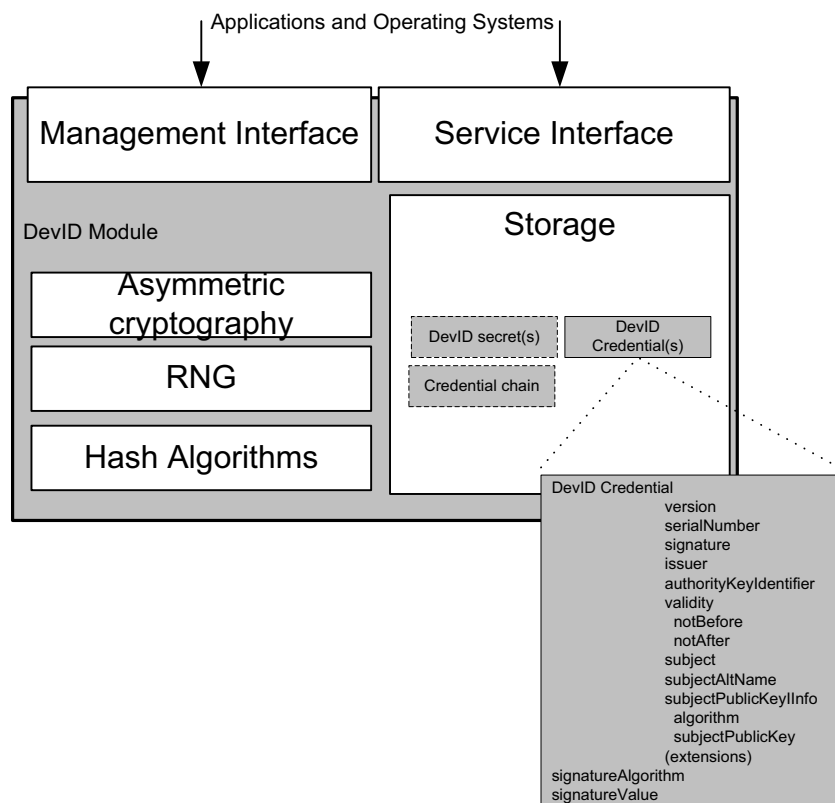


Figure 6-1— DevID components

A DevID (particularly an IDevID) continues to exist for as long as the DevID module it exists in remains operational. In order to support the standard X.509 certificate format, a certificate expiry time is specified. The GeneralizedTime value “99991231235959Z” is used for this purpose.

The CA certificates of the certificate chain shall conform to the IDevID specification as specified in 7.1 (DevID hierarchy credential fields).

6.2.2 Asymmetric cryptography

The DevID secret shall be either the secret portion of a RSA private-public key pair as defined in 7.3.1 (RSASSA-PKCS1-v1.5) or the secret portion of an P-256 elliptic curve private-public key pair as defined in 7.3.2 (ECDSA).

Since the DevID secret is used only within the DevID module in which it is installed, the underlying representation is a choice left to the implementer. Possible representations are discussed in 6.2.5 (Storage) along with estimates of the storage requirements.

Techniques for finding a suitable DevID secret are discussed in IEEE Std 1363™-2000 [B4] and NIST FIPS 186-3.

6.2.3 Hash algorithms

The DevID Module shall contain an implementation of the hash algorithm as specified in 7.3.3 (SHA-256 hash algorithm).