

LWIG Working Group
Internet Draft
Intended status: Experimental

P. Urien
Telecom Paris

June 15 2021

Expires: December 2021

Security Classes for IoT devices
draft-urien-lwig-security-classes-06.txt

Abstract

This draft attempts to define security classes for constraint IoT devices. A device security is characterized by five Boolean security attributes: one time programmable memory (OTP), firmware loader (FLD), secure firmware loader (FLD-SEC), tamper resistant key (TRT-KEY) and diversified key (DIV-KEY).

This leads to the definition of 6 classes of devices, embedding or not OTP resource, whose security increases with the class number (0 to 5). The suffix + indicates OTP availability.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC 2119](#).

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <http://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on December 2021.

.

Copyright Notice

Copyright (c) 2021 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](#) and the IETF Trust's Legal Provisions Relating to IETF Documents (<http://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the [Trust Legal Provisions](#) and are provided without warranty as described in the Simplified BSD License.

Table of Contents

Abstract.....	1
Requirements Language.....	1
Status of this Memo.....	1
Copyright Notice.....	2
1 Overview.....	4
2 Security Attributes.....	6
2.1 One Time Programmable Memory, OTP.....	6
2.2 Firmware Loader, FLD.....	6
2.3 Secure Firmware Loader, FLD-SEC.....	6
2.4 Tamper Resistant Key, TRT-KEY.....	7
2.5 Diversified Key, DIV-KEY.....	7
3 IANA Considerations.....	7
4 Security Considerations.....	7
5 References.....	7
5.1 Normative References.....	7
5.2 Informative References.....	7
6 Authors' Addresses.....	8

1 Overview

This draft attempts to define security classes for IoT devices, supporting SUIIT [SUIT] protocols. The goal is to provide a qualitative estimation of risks induced by firmware remote updates according to device logical and hardware security resources.

According to this draft a device comprises a main processor (MP), an optional communication processor (CP), actuators and/or sensors. The communication task may be handled by the main processor. The main processor manages the update of other processor(s).

The main processor embeds several types of memories:

- One Time Programmable Memory (OTP)
- Non Volatile Memory (NVR)

The logical architecture of the optional communication processor is similar to those of the main processor.

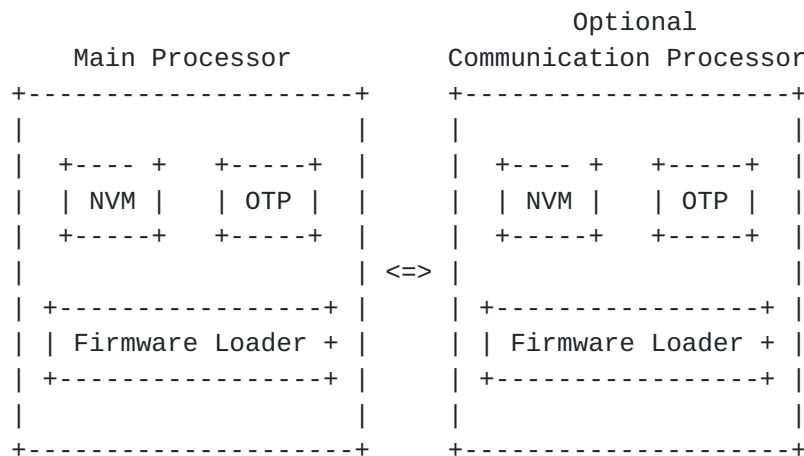


Figure1. Device architecture

Firmware update MAY be handled by a firmware loader (FLD) entity, and/or by other physical protocols (PHYP), for example Serial Programming (SP) or Parallel Programming (PP).

When OTP memory is available, it stores a permanent part of the update procedure (named firmware loader in this draft).

Non volatile memory such as FLASH may be fully erased. When no OTP is available the main processor may be totally reprogrammed through physical protocols; i.e. physical access to the device may lead to its full control.

A firmware loader enables the remote update of the NVR of the main processor. It MAY be secure (FLD-SEC) or not. If it is secure, a symmetric or asymmetric procedure (and associated keys) is used in order to check the firmware authenticity. The two main classes of

security procedures deal with symmetric algorithms (for example AES-

Urien

Expires December 2021

[Page 4]

CCM) or asymmetric signatures (for example ECDSA). It MAY support post quantum [POSTQUANTUMCRYPTO] cryptographic algorithms.

Even if the firmware loader is secure, cryptographic keys may be recovered by side-channel attacks [[SIDECHANNEL](#)][DIVKEY]. Therefore Tamper Resistant key (TRT-KEY) is a very important attribute. The impact of a side channel attack may be limited to a single object if the keys are diversified (DIV-KEY).

We propose to characterize a device by a set (SecAtt) of five boolean attributes (0/1).

SecAtt = {OTP, FLD, FLD-SEC, TRT-KEY, DIV-KEY}

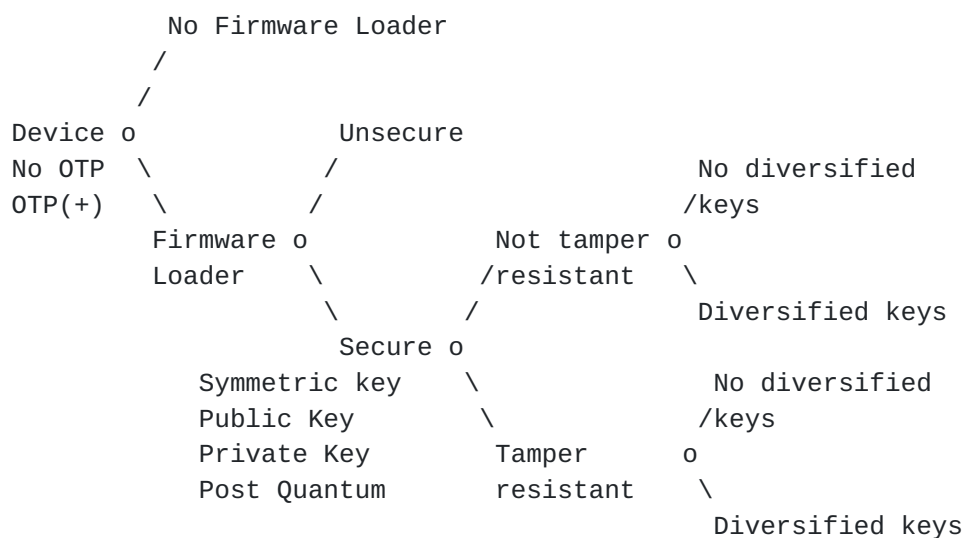


Figure2. Security classes

This leads to the definition of 6 classes of devices, embedding or not OTP resource, whose security increases with the class number. The suffix + indicates OTP availability.

Class0/Class0+ = {0/1,0}, no firmware loader, other attributes (excepted OTP) are not taken into account.

Class1/Class1+ = {0/1,1,0,0,0}, unsecure firmware loader

Class2/Class2+ = {0/1,1,1,0,0}, secure firmware loader, not tamper resistant, no diversified keys

Class3/Class3+ = {0/1,1,1,0,1} secure firmware loader, not tamper resistant, diversified keys

Class4/Class4+ = {0/1,1,1,1,0} secure firmware loader, tamper resistant, no diversified keys.

Class5/Class5+ = {0/1,1,1,1,1} secure firmware loader, tamper resistant, diversified keys.

For example

- Class0 objects are uploaded (flushed) thanks to physical protocols, and as an illustration may be updated via HTTPS requests.

Urien

Expires December 2021

[Page 5]

- Many micro-controller units (MCU) support an unsecure bootloader and belong to Class1.
- Some USB flash drives [[BADUSB](#)] belong to Class1+; they include an unsecure bootloader stored in ROM.
- Some smart bulbs [DIVKEYS] devices are Class2 devices; they use secure bootloader with a single symmetric key shared by multiple devices
- SUIIT protocols SHOULD target secure bootloader with public key i.e. Class2+, or secure bootloader with diversified symmetric key i.e. Class3+.
- Class4 uses a secure bootloader, with a single key shared by multiple devices, and protected by tamper resistant means.
- Highly secure devices similar to bank cards belong to Class5+.

More details are available in [[IOTSEC](#)].

2 Security Attributes

2.1 One Time Programmable Memory, OTP

The OTP attribute means that the main processor stores permanent software typically a firmware loader or a subset of this entity.

If no OTP is available the full memory content of the main processor can be erased and fully updated. No minimum device behavior is guaranteed in this case.

2.2 Firmware Loader, FLD

A firmware loader is mainly a command interpreter that enables logical/remote firmware update. It avoids the use of physical procedures such as Serial Programming a Parallel Programming. It is stored either in non erasable or erasable non volatile memory.

2.3 Secure Firmware Loader, FLD-SEC

A secure bootloader checks the authenticity and integrity of firmware updates by cryptographic means. This implies the use of symmetric secret keys, asymmetric private keys, or asymmetric public keys associated to certificates. Most of cryptographic algorithms may be broken by side-channel attacks.

If a long term vision is required it MAY support post quantum [POSTQUANTUMCRYPTO] cryptographic algorithms. Quantum computer may break asymmetric algorithm dealing with RSA or elliptic curves. In case of symmetric cryptography the recommended key size is about 256 bits.

2.4 Tamper Resistant Key, TRT-KEY

Cryptographic keys may be recovered by side-channel attacks. A tamper resistant computing environment SHOULD avoid these attacks.

2.5 Diversified Key, DIV-KEY

The use of diversified secret keys limits the side channel attack scope to a single object. The lack of tamper resistant computing and the use of single secret shared by multiple nodes MAY create major security threats.

3 IANA Considerations

This draft does not require any action from IANA.

4 Security Considerations

This draft attempts to define security classes for constraint IoT devices.

5 References

5.1 Normative References

[SUIT], Moran, B., Meriac, M., Tschofenig, H., and D. Brown, "A Firmware Update Architecture for Internet of Things Devices", [draft-ietf-suit-architecture-09](#) (work in progress), May 2020.

5.2 Informative References

[SIDECHANNEL] David Oswald, "IMPLEMENTATION ATTACKS: FROM THEORY TO PRACTICE DISSERTATION", zur Erlangung des Grades eines Doktor ingenieurs der Fakultät für Elektrotechnik und Informationstechnik an der Ruhr-Universität Bochum, Bochum, September 2013

[DIVKEY] Eyal Ronen and Colin O'Flynn and Adi Shamir and Achi-Or Weingarten, "IoT Goes Nuclear: Creating a ZigBee Chain Reaction", Cryptology ePrint Archive, Report 2016/1047.

[POSTQUANTUMCRYPTO] Vasileios Mavroeidis, Kamer Vishi, Mateusz D. Zych, Audun Josang, "The Impact of Quantum Computing on Present Cryptography", International Journal of Advanced Computer Science and Applications (IJACSA), 9(3), 405-414, March 2018

[BADUSB] Karsten Nohl, Sascha Kribler, Jakob Lell, "BadUSB - On Accessories that Turn Evil", Blackhat USA 2014.

[IOTSEC] Pascal Urien, "Integrity Issues for IoT: From Experiment to Classification Introducing Integrity Probes", In proceedings of 4th

International Conference on Internet of Things Big Data, and
Security, IoTBDS19, May 2019

6 Authors' Addresses

Pascal Urien
Telecom Paris
19 place Marguerite Perey
23 avenue d'Italie
91120 Palaiseau Phone: NA
France Email: Pascal.Urien@telecom-paris.fr