Trust Your Firmware: Secure Boot for Application Processors

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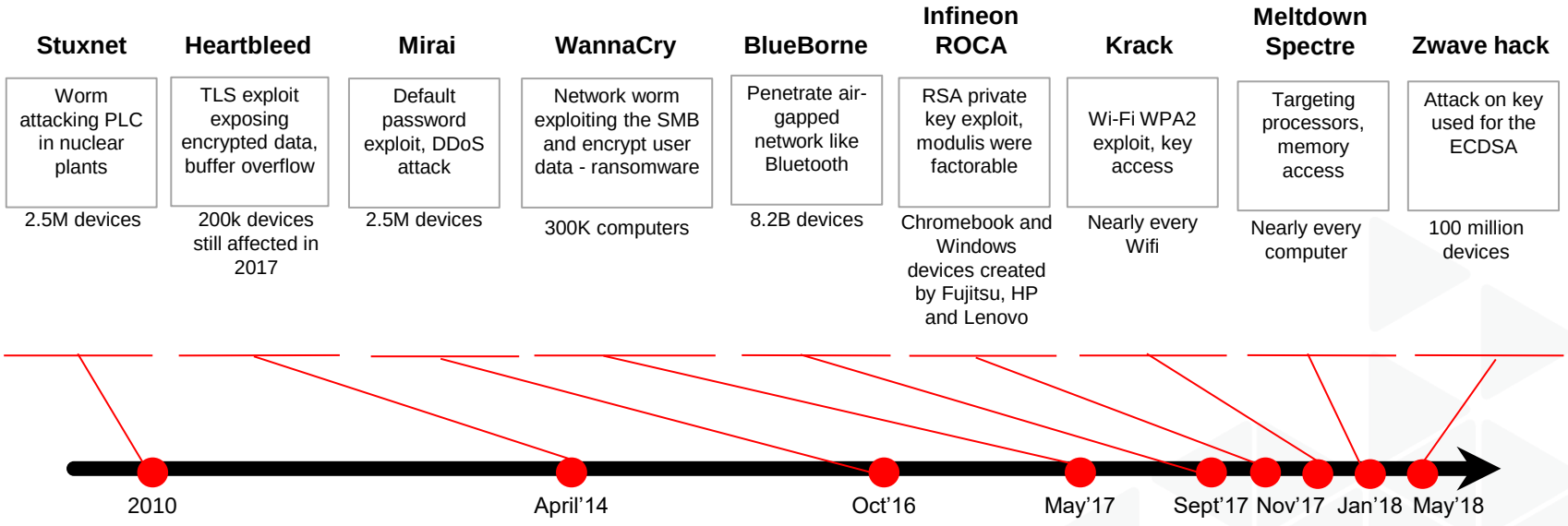
Acceleration in Attacks:



The increase in connected devices accelerates hackers' interests

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The Impact

Your brand

Your Company

Your Revenue

Your IP

Your Customers

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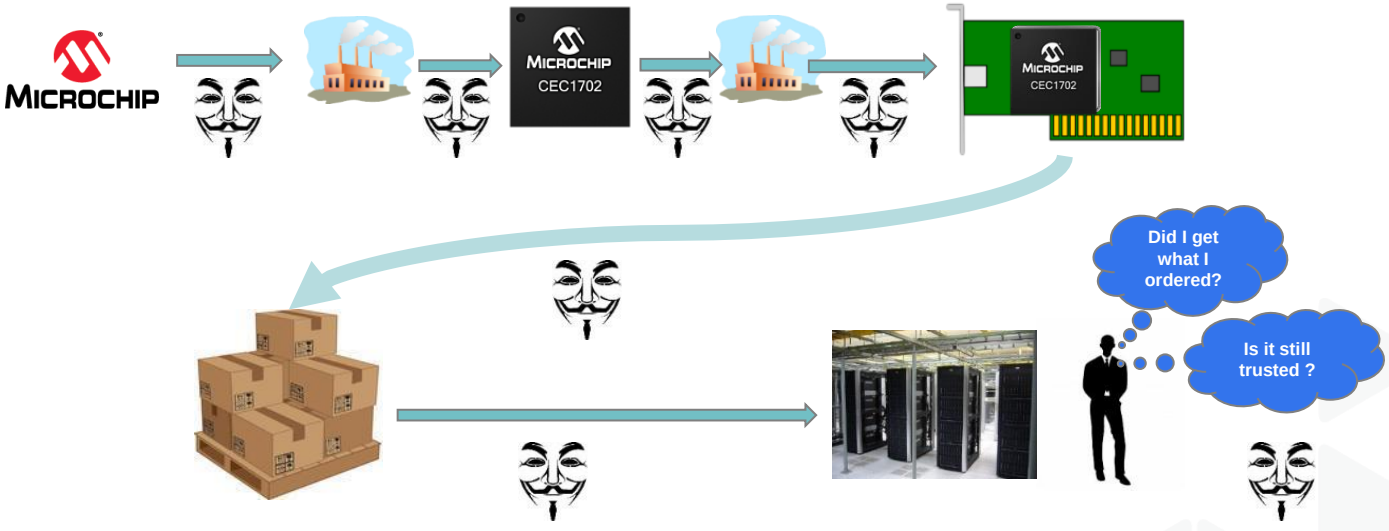
Trusted Platforms – Why the need?



- Various Points of entry
- Where has the product been ?
- Is it really the expected product?
- Was it intercepted in flight ?

- Is it running altered firmware / hardware ?
- Does it contain the intended components ?
- Will it stay that way ?
- Is the product genuine ?

Security Threats Along the Way of Manufacturing & Deploying

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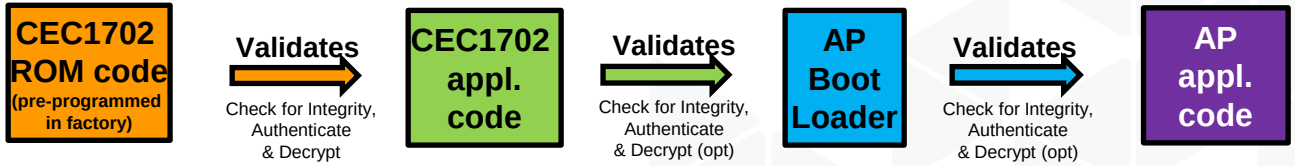
What is Secure Boot?

- Silicon HW Root of Trust
- Security begins with the Root of Trust
  - Embedded Signing Keys
  - Strong Hashing Functions
  - Immutable Authenticating Boot logic in Silicon Boot ROM
- Board Components enablement and Security
  - Trust is extended by verifying the authenticity and integrity of FLASH content prior to executing it
  - Digital signatures are supplied with all Firmware and Configuration Binaries
  - Validated with Embedded ASIC signing keys
  - ASIC Calculated hashes are computed against the stored images and compared with stored signatures.

- Why is Secure Boot Important?
  - Protects a system against threats before they can attack or infect it
  - System boots using only software trusted by the manufacturer
  - Prevents malicious software (i.e Root Kits) from loading during system start-up process

Root of Trust



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CEC1702 Crypto Embedded Controller

Product Features

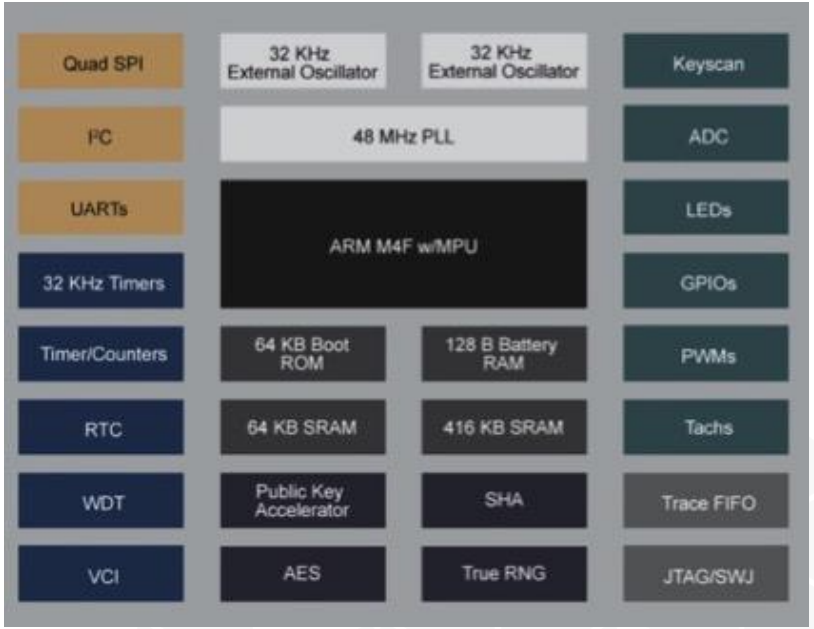
- ARM® Cortex®-M4F microcontroller
- 480KB SRAM: Code + Data
- 64KB Boot ROM
- Fast, hardware based cryptography cipher suite
- Robust HW Crypto Cypher Suite
- ECDSA, EC-KCDSA, Ed25519
- 2.5K bits User Programmable OTP

Typical Applications

- Secure Boot of Application Processors
- Industrial IoT Connected Devices

Differentiators

- Secure boot provides a immutable chain of trust



CEC1702 can be used for secure boot and to authenticate subsequent code loaded/running on CEC1702 or other devices in the system (field upgrades)

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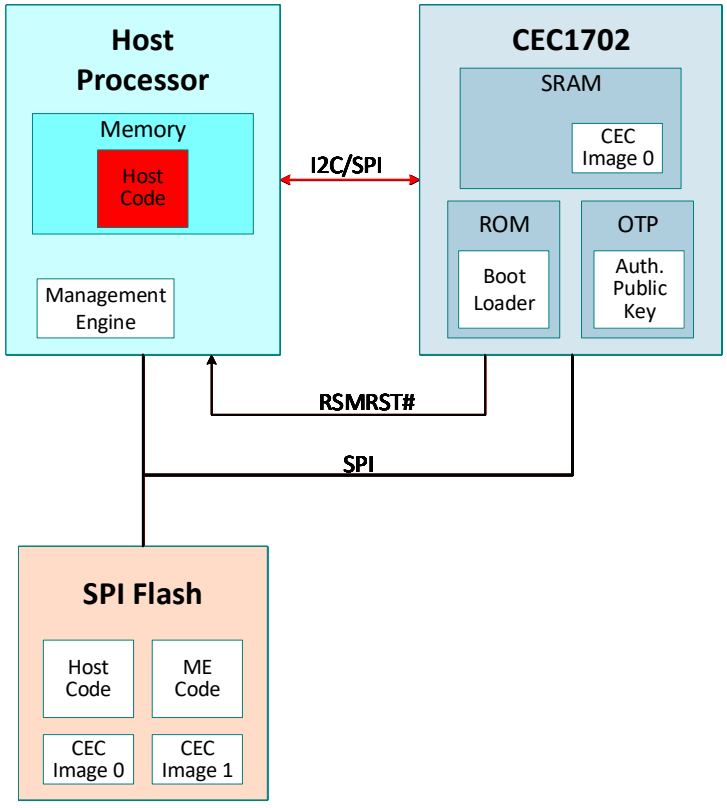
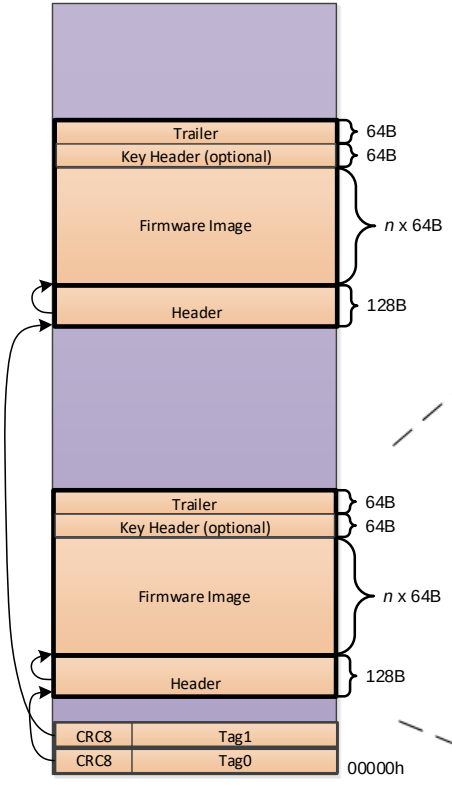
Hardware Root of Trust



- Code execution starts with the ROM
  - Hardware based: Trusted immutable code (Boot Loader)
  - Cannot be modified remotely
  - Creates a Root of Trust
- SPI Flash
  - Application code, signed by OEM's private key, is stored in SPI Flash (CEC Image 0 & 1)
  - Host code, signed by a private key, is also stored in the SPI Flash
- At power-on, the Boot Loader
  - Holds Host Processor in reset
  - Loads CEC1702 Application Code from SPI Flash into SRAM and
  - Authenticates CEC1702 Application Code using public key stored in CEC1702 OTP
- The authenticated CEC1702 Code
  - Starts execution
  - Authenticates the system Host code in SPI Flash with a public key in CEC1702 code
  - Releases the Host Processor from reset
- The Host Processor then loads and executes its authenticated code from SPI Flash
- Chain of Trust is now extended to
  - CEC1702 Application Code
  - Host code
- The Host Processor can also use the CEC1702 as a crypto-coprocessor

SPI Flash Image Structure

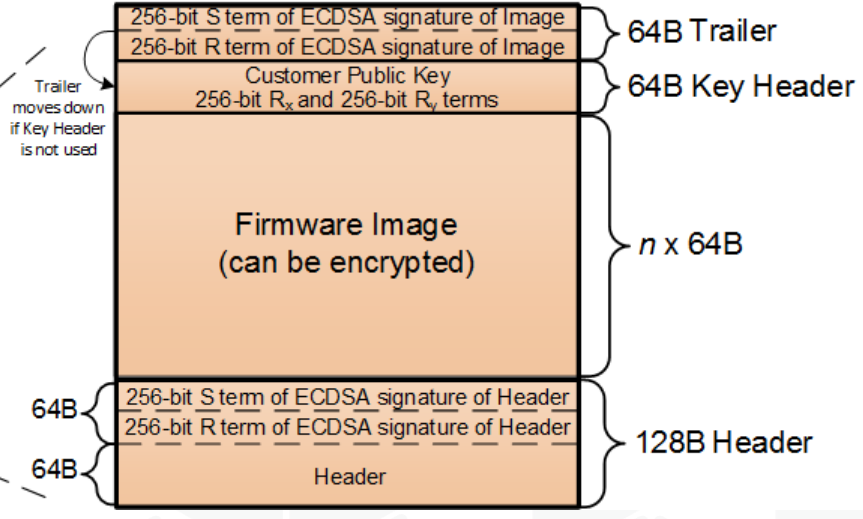


Note – SPI Flash contains two images of CEC1702 code:

Tag0

Tag1

Expanded view of FW image



CEC1702 HW Crypto Cipher Suite

	CEC1702
Symmetric Encryption – runs @ 48MHz	AES128, AES192 and AES256
	Modes: ECB, CBC, OFB, CFB, CTR
	One cycle per byte
	100x faster than FW
	Saves up to 8KB-15KB code
Hashing – runs @ 48MHz	SHA-1, SHA-256, SHA-512 (programmable 224 and 384)
	One cycle per byte
	100x faster than FW
	Saves up to 2KB code
Public Key Engine (PKE) – runs @ 96MHz	20x-50x faster than FW
RSA	RSA-1024 to RSA-4096
ECC	Keys with 192 to 640 bits in GF(p) – programmable Keys with 160 to 640 bits in GF(2m) – programmable Curve25519 (ECDSA support) – example, also support BP, etc.
DSA	ECDSA, EC-KCDSA, Ed25519
Other	Secure Remote Password (SRP) Modular Arithmetic Primitives Miller-Rabin Primality Testing
Random Number Generator	True RNG
	1K FIFO for pre-calculation
Monotonic Counter	Yes
User Programmable OTP (in addition to key space)	2.5K bits
Memory Protection Unit	Yes

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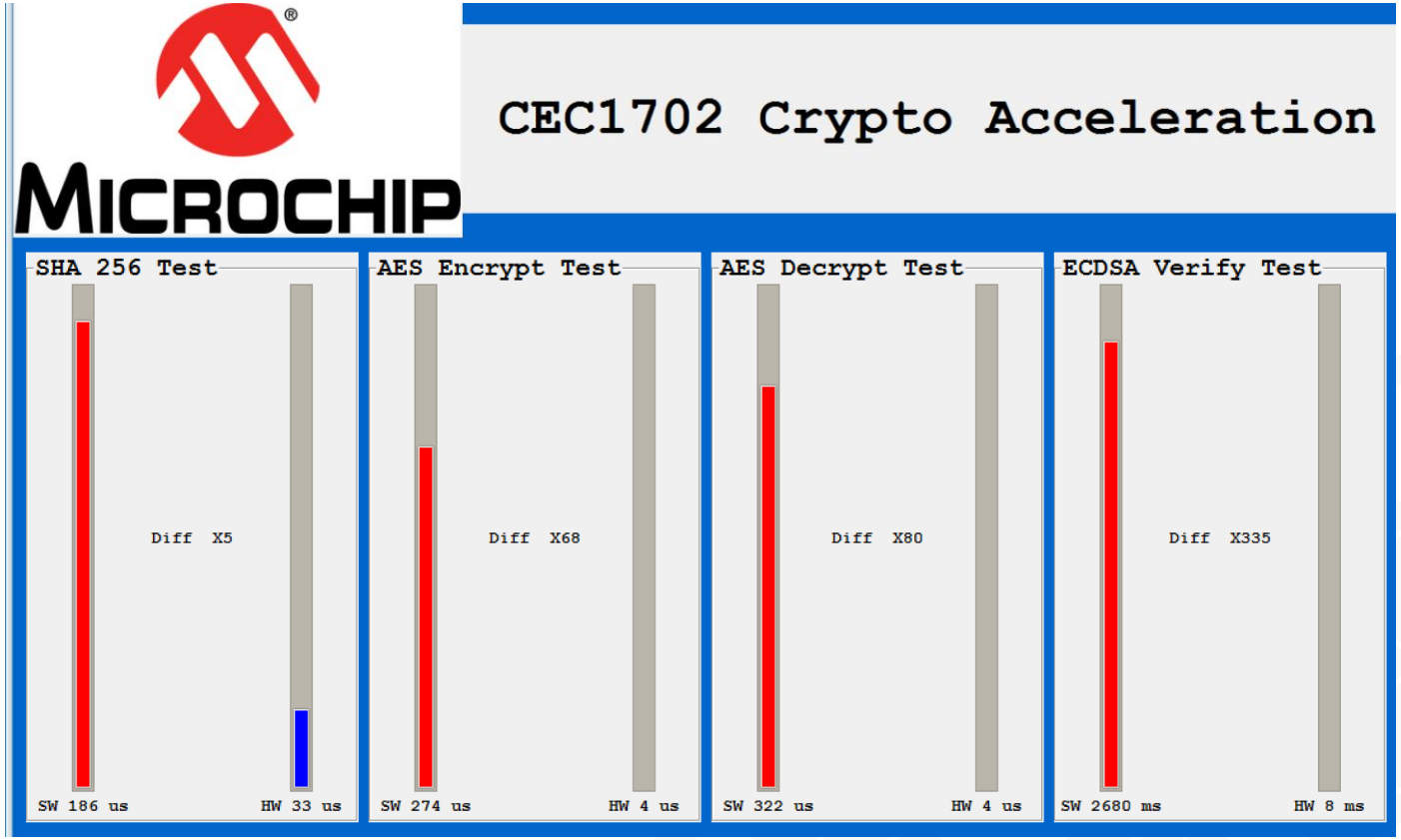
Benefit of HW Crypto



CEC1702 CAVP Validations

Cryptographic Algorithm Validation Program (CAVP)

- In July 1995, NIST and the Communications Security Establishment Canada (CSEC) established the Cryptographic Algorithm Validation Program (CAVP)
- This program focuses on validation testing for NIST recommended, and FIPS 140-2 approved cryptographic algorithms

CEC1702 has received CAVP Validation #s:

- C592: https://csrc.nist.gov/projects/cryptographic-algorithm-validation-program/details?product=10951
- SHS3823: https://csrc.nist.gov/projects/cryptographic-algorithm-validation-program/Details?validation=2091

Algorithm Capabilities Validated:

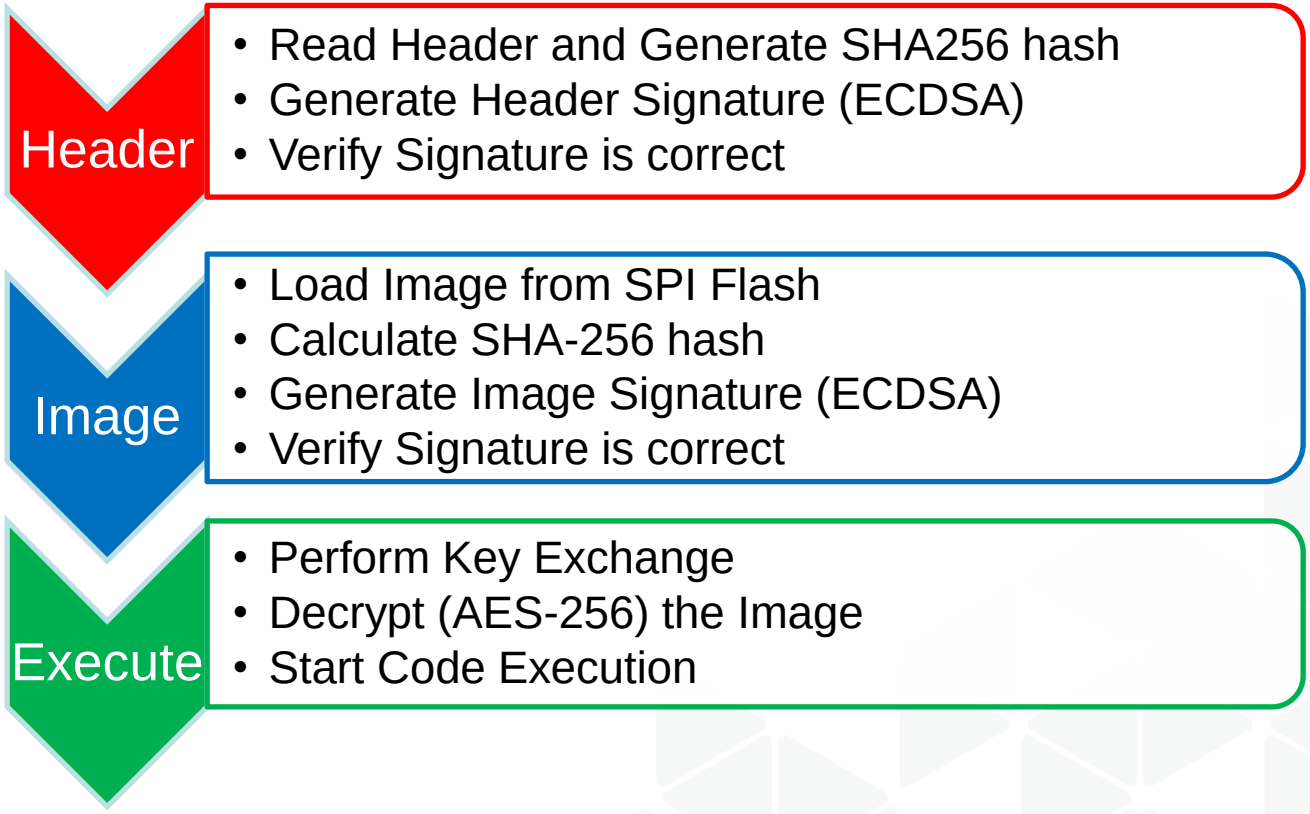
AES-CBC	Counter DRBG	KAS-ECC CDH-Component	SHA-1
AES-CFB128	ECDSA KeyGen (186-4)	RSA KeyGen (186-4)	SHA-224
AES-CFB8	ECDSA KeyVer (186-4)	RSA SigGen (186-2)	SHA-256
AES-CTR	ECDSA SigGen (186-4)	RSA SigGen (186-4)	SHA-384
AES-ECB	ECDSA SigGen (186-4)	RSA SigVer (186-4)	SHA-512
AES-OFB	ECDSA SigVer (186-4)		

Fast Secure Boot

Read Header	
Read Header and generate SHA-256 hash	0.4ms
Verify Header Signature (ECDSA)	11.7ms
Load Image	
Load from SPI, 300K	12.7ms
Calculate SHA-256 hash	8.4ms
Verify Image Signature (ECDSA)	10.5ms
Decrypt Image	
Key Exchange	5.9ms
AES-256 Decrypt	11.9ms
TOTAL	**61.5ms**

Secure boot using firmware cryptographic functions will take ~2.5s

Image Authentication



CEC1702 & NIST 800-193

Protect

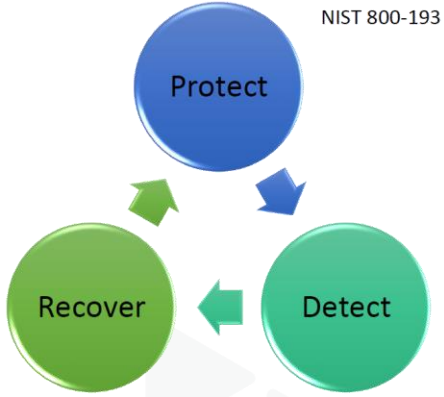
- CEC1702 will only execute Authenticated Code
- Code Update
  - Image is signed (ECDSA) by owner prior to transmittal
  - Image is written to SPI Flash – Staging Area
  - CEC1702 will authenticate the signed image update
  - After Authentication, Updated Code is written to Active Area

Detect

- All code is verified using SHA256 and Authenticated with ECDSA using P-256

Recover

- CEC1702 Firmware
  - Two code images implemented (Tag0 & Tag1)
  - Initial Boot is from Tag0
  - If Tag0 is corrupted switch and use Tag1
  - Automatically handled by Boot Loader
- Application Processor Code
  - Can support using a backup or Golden image to restore the system to a known good state if the Host code is corrupted



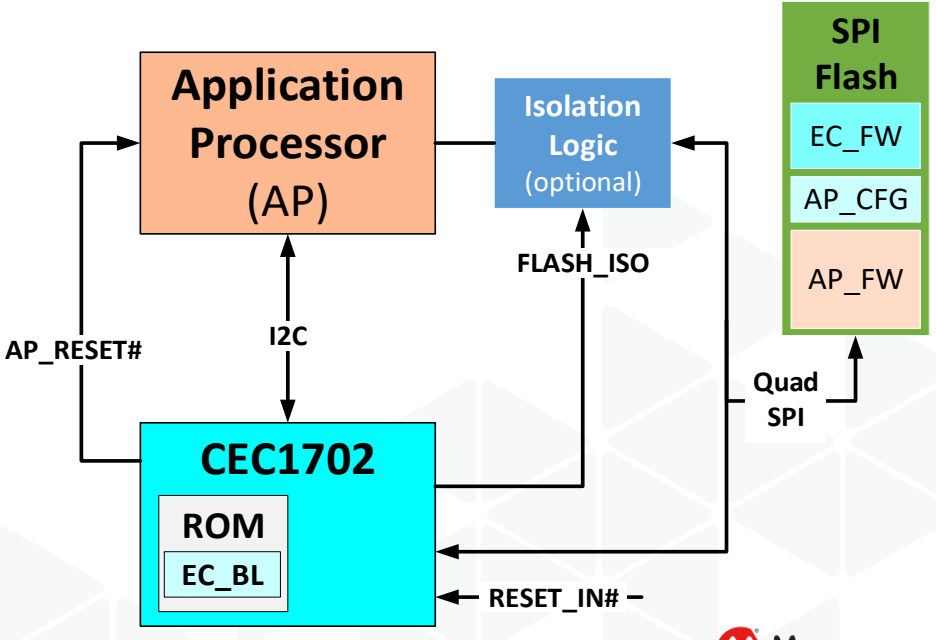
Microchip Soteria

A Microchip FW solution for Microchip CEC1702

Key Features

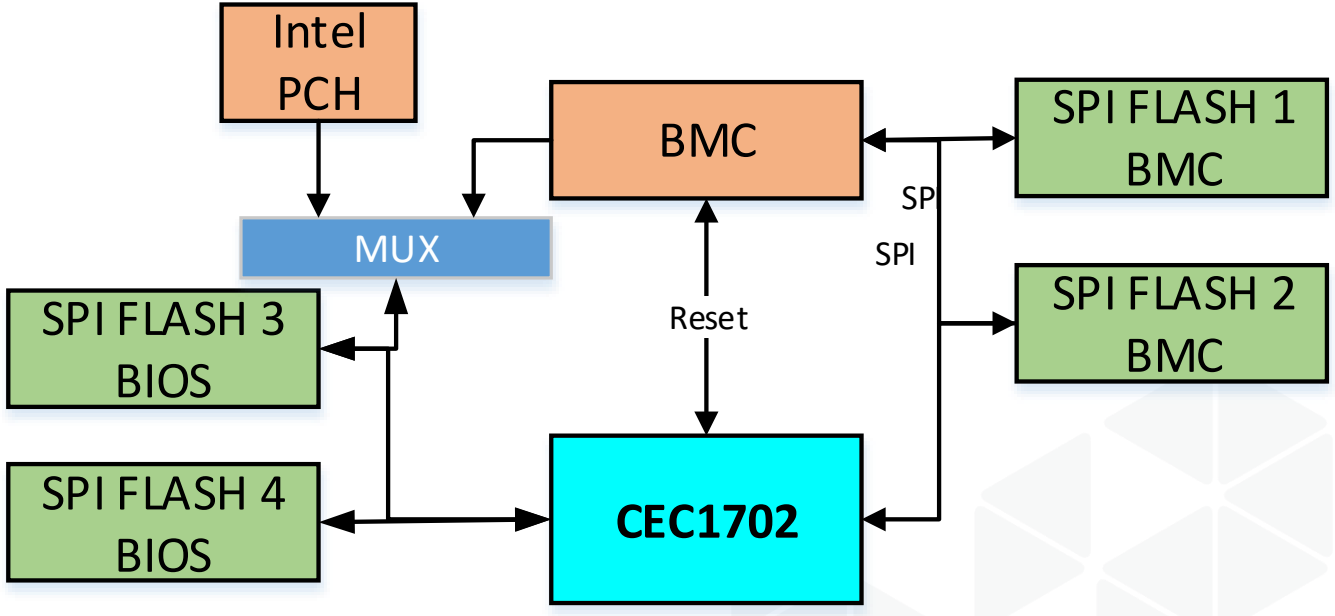
- Secure Boot / Platform-RoT
- Pre-boot Authentication of AP FW
- Authentication of FW Updates

User Configurable and Customizable



Soteria Scalability

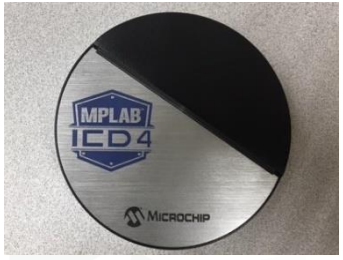
Soteria scales to multiple APs with multiple SPI-flash



Development Tool Support

CEC1702 is supported by Microchip's award winning MPLAB development tools

- MPLAB X32 Compiler
- MPLAB REAL ICE in-circuit emulator
- ICD 4 in-circuit debugger



Also supported: Keil, IAR, ARM GCC and Seggar IDE

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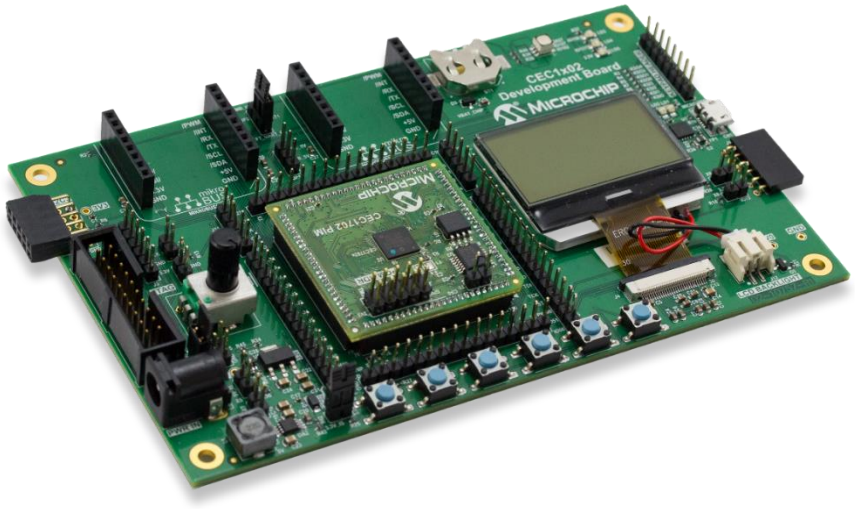
CEC1702 Development Board



- The CEC1702 Development Board is an evaluation board that can be used for development, customer evaluation and demos.
- Customers can evaluate and program keys used for authentication into the CEC1702 devices.
- The packaged CEC1702 Development Board includes the base board and a CEC1702PIM.

Available on MicrochipDirect

Part Number: DM990013
Price: $125 USD

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CEC1702 Support Collateral

Datasheets / Errata

- CEC1702 Datasheet & ROM Description Addendum
- I2C / SMBus Interface Core Specification
- CEC1702 Silicon Errata and Data Sheet Clarification

Application Notes

- PCB Layout Guide for CEC1702
- BSDL Models for CEC1702
- Peripheral and Crypto Library API Release Package (Users Guide)
- Secure Provisioning Release Package (Utility and Users Guide)

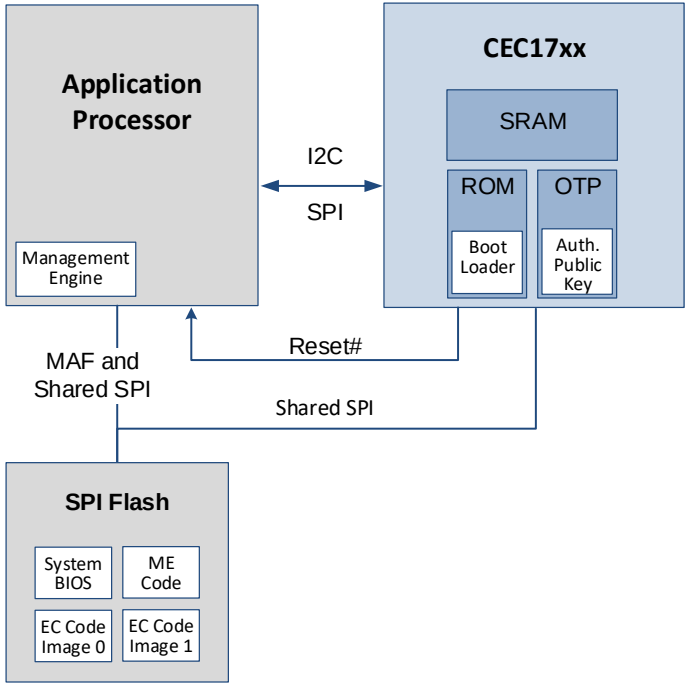
Software and Sample Code

- Blinking LEDs Sample Code by mikroE sample project
- CEC1702 CLIB/PLIB Release
- CEC1702 mikroE SDK (update April 2019)
- AWS IoT SDK for CEC1702
- Azure DICE IoT SDK for CEC1702
- Masters Hand-On Training Class Package
- ECC508 Sample Code and App Note

Utilities

- SPI Image Generators
- eFuse Generator Utility for CEC1702
- Secure Firmware update Utility for CEC1702

Summary



- Hardware Root of Trust – Secure Boot Solution
- Secure any processor using SPI flash
- Boot Rom Authenticates CEC17xx code in SPI Flash
- CEC17xx code authenticates Application processor code in SPI flash
- All authentication prior to code running
- Authentication at every power cycle
- CEC1702 Meets NIST Guidelines

www.microchip.com/CEC1702