# 2024 Design Document

*Secure MISC*

0xDACC

April 2, 2024

# 1 Proposed List Changes

**Use standard I2C packet structure**

| Header | | Payload |
|---|---|---|
| Packet Magic | Checksum | Length |
| (1 byte) | (4 bytes) | (1 byte) |
| | | 0x00 |

Table 1: List Packet

| Header | | Payload | |
|---|---|---|---|
| Packet Magic | Checksum | Length | Data |
| (1 byte) | (4 bytes) | (1 byte) | (4 bytes) |
| | | 0x04 | |

Table 2: List Response Packet

# 2 Proposed Attest Changes

**Store attestation PIN as a hash with enough rounds that it takes approximately 2 seconds.**

- Limits brute force attempts
- Makes raw PIN unable to be extracted from flash

**Wrap attestation symmetric key with attestation PIN hash**

**Store attestation data encrypted with unwrapped symmetric key**

- Also limits brute force and makes PIN unreadable from flash

**Meets SR3 and SR4**

| Header | | Payload | | |
|---|---|---|---|---|
| Packet Magic | Checksum | Length | Data | Signature |
| (1 byte) | (4 bytes) | (1 byte) | (6 bytes) | (64 bytes) |
| | | 0x06 | 0x415454455354 | |

Table 3: Attestation Data Packet

| Header | | Payload | | |
|---|---|---|---|---|
| Packet Magic | Checksum | Length | Attestation Data | Signature |
| (1 byte) | (4 bytes) | (1 byte) | (192 bytes) | (64 bytes) |
| | | 0xC0 | | |

Table 4: Attestation ACK Packet

# 3 Proposed Replace Changes

**Store replacement token as a hash**

- Makes token unable to be extracted from flash
- Highly unlikely that the token can be brute forced

**Verify component authenticity**

1. Store replacement public key in flash
2. Generate a random number using onboard TRNG
3. Ask new component to sign random number
4. Verify using replacement public key

| Header | | Payload | |
|---|---|---|---|
| Packet Magic | Checksum | Length | Data |
| (1 byte) | (4 bytes) | (1 byte) | (32 bytes) |
| | | 0x20 | |

Table 5: Replace Data Packet

| Header | | Payload | |
|---|---|---|---|
| Packet Magic | Checksum | Length | Signature |
| (1 byte) | (4 bytes) | (1 byte) | (64 bytes) |
| | | 0x41 | |

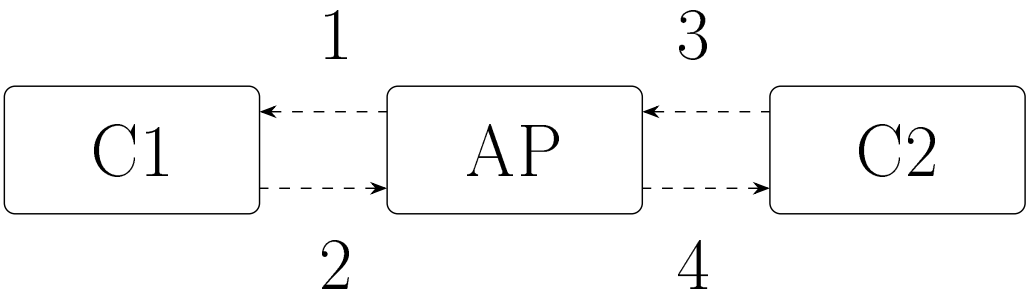
Table 6: Replace ACK Packet

**Meets SR3**

# 4 Proposed Boot Changes

**Verify integrity of all 3 boards**

- Store public key C and private key A on AP
- Store public key A and private key C on Components




1. AP verifies Component1
   (a) AP generates a random number and asks Component1 to sign with key C
   (b) AP verifies signature using key C
2. Component1 verifies AP
   (a) Component1 generates a random number and asks AP to sign with key C
   (b) Component1 verifies signature using key C
   (c) Component1 boots
3. AP verifies Component2
   (a) AP generates a random number and asks Component2 to sign with key C

(b) AP verifies signature using key C

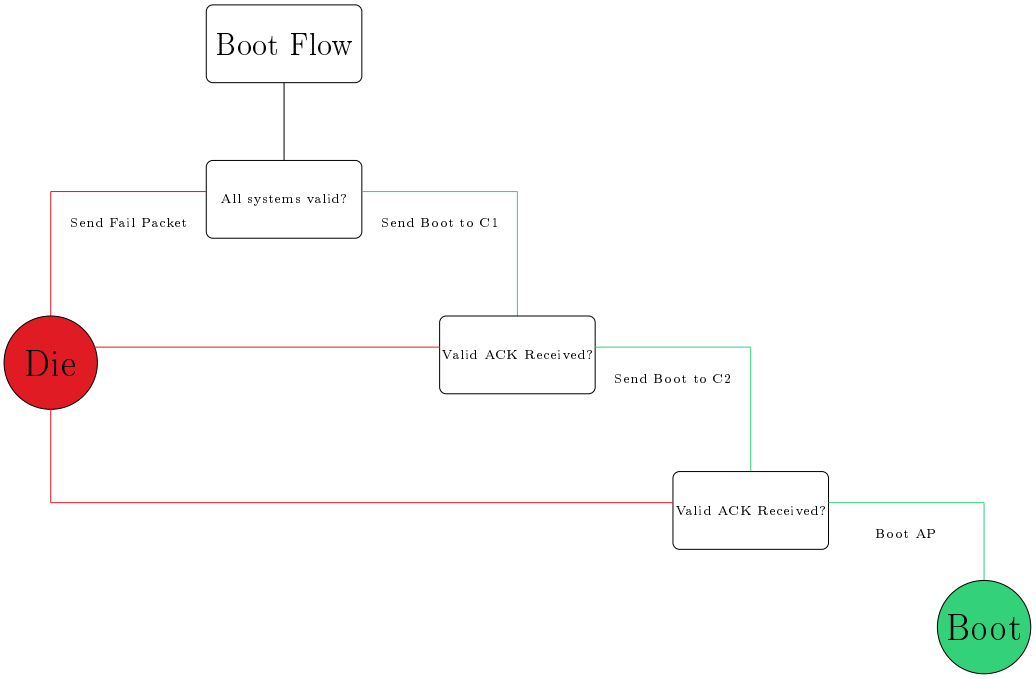
4. Component2 verifies AP
   (a) Component2 generates a random number and asks AP to sign with key A
   (b) Component2 verifies signature using key A
   (c) Component2 boots
5. AP verifies ComponentN
   (a) AP generates a random number and asks ComponentN to sign with key C
   (b) AP verifies signature using key C
6. ComponentN verifies AP
   (a) ComponentN generates a random number and asks AP to sign with key A
   (b) ComponentN verifies signature using key A
   (c) ComponentN boots
7. AP Boots

***If any signatures are invalid, stop immediately and shut down.***

**If:**

- Packet Magic != Expected Magic
- CSUM(Payload) != Expected Checksum
- Length != 0x40
- ecrecover(signature) != key A or key C

***Shut down immediately, send fail packet if running on component, and do not continue operation.***




**Meets SR1 and SR2**

| Header | | Payload | | |
|---|---|---|---|---|
| Packet Magic | Checksum | Length | Data | Signature |
| (1 byte) | (4 bytes) | (1 byte) | (32 bytes) | (64 bytes) |
| | | 0x60 | | |

Table 7: Component Boot Packet

| Header | | Payload | | |
|---|---|---|---|---|
| Packet Magic | Checksum | Length | Boot Message | Signature |
| (1 byte) | (4 bytes) | (1 byte) | (64 bytes) | (64 bytes) |
| | | 0x40 | | |

Table 8: Boot ACK Packet

# 5 Proposed Secure TX Changes

**ECIES Based Scheme**

- Generate private key using RNG
- Create an encrypted channel even though unnecessary.
- Confidentiality will be provided to make RE'ing just a tiny bit harder
- Encrypt packets with negotiated key
- Negotiate HMAC key over new channel
- Append HMAC to all packets before encrypting
- Calculate checksum of encrypted data

**If:**

- Packet Magic != Expected Magic
- CSUM(packet) != Expected Checksum
- Payload Magic != Expected Magic
- HMAC(Data) != HMAC or Hash(Key) != Key Hash
- Nonce != Expected Nonce

***Shut down immediately, send fail packet, and do not continue operation.***

**Meets SR5**

| Header | | Encrypted Payload | | | | |
|---|---|---|---|---|---|---|
| Packet Magic | Checksum | Payload Magic | Length - 1 | Nonce | Data | HMAC |
| (1 byte) | (4 bytes) | (1 byte) | (1 byte) | (4 bytes) | (256 bytes) | (32 bytes) |
| | | 0xDD | | | | |

Table 9: Encrypted I2C Packet

| Header | | Payload | | |
|---|---|---|---|---|
| Packet Magic | Checksum | Length | Key Material | Key Hash |
| (1 byte) | (4 bytes) | (1 byte) | (64 bytes) | (32 bytes) |
| | | 0x60 | | |

Table 10: Key Exchange I2C Packet

# 6 Other

**Secure key storage**

- All asymmetric and symmetric keys located on flash will be stored in an encrypted state
- Wrapper keys will be compile-time constants and XOR'ed with another compile-time constant so the raw key will *NEVER* be stored in flash
- By wrapping all keys, a flash dumper payload would not be able to extract the real keys and static reverse engineering would have a similar outcome

# 7 Summary

## 7.1 SR1 All components must be valid for AP to boot

- Validate all component's integrity through signing an arbitrary number
- Components then validate the AP to make sure all systems are present and valid
- Boot the AP

## 7.2 SR2 All components must be validated by AP and commanded before booting

- After a successful handshake, it can be assumed that all components are valid
- Send signed boot command to components from AP
- Boot individual components

## 7.3 SR3 The Attestation PIN and Replacement Token should be kept confidential

- PIN will be stored as a hash with enough iterations to reduce the brute force likelihood
- Replacement Token will also be stored as a hash

## 7.4 SR4 Component Attestation Data should be kept confidential

- Attestation Data will be stored with symmteric encryption with the key being derived from the Attestation PIN

## 7.5 SR5 Integrity and Authentication of all communications

- All messages will follow a standard packet format with a negotiated HMAC key and assymetric encryption

- A nonce and ephermeral keys may be included to limit replay attacks