Hardware Digital Signatures

Lionello Lunesu
Enuma Technologies Limited

lio@enuma.io

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Why?

- SSL certificates (HTTPS)
- Bitcoin transactions
- Ethereum smart contracts
- Document signing (PDF)
- Debit/credit card (EMV)
- Message authentication (Signal/WhatsApp)
- DomainKeys Identified Mail (DKIM)

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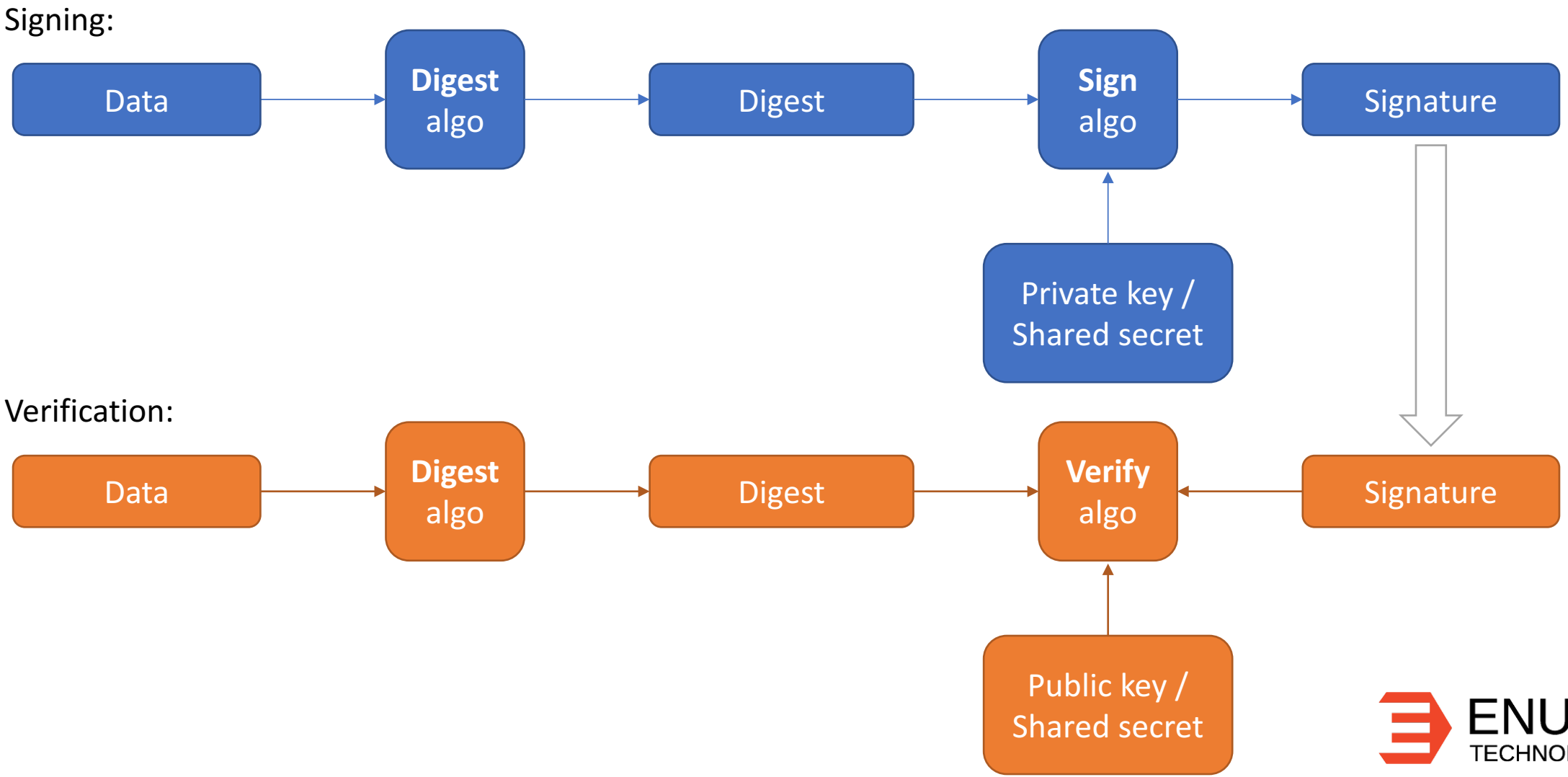
Digital Signatures



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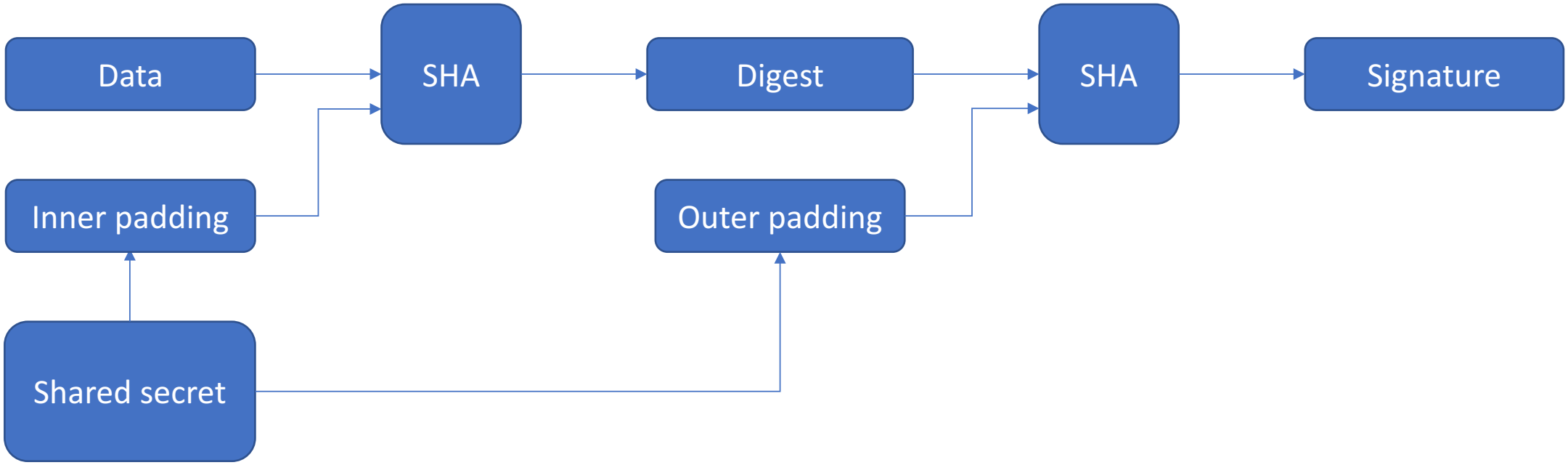
Digital Signatures : HMAC



Both the signer and verifier follow the same process and compare the final signature.

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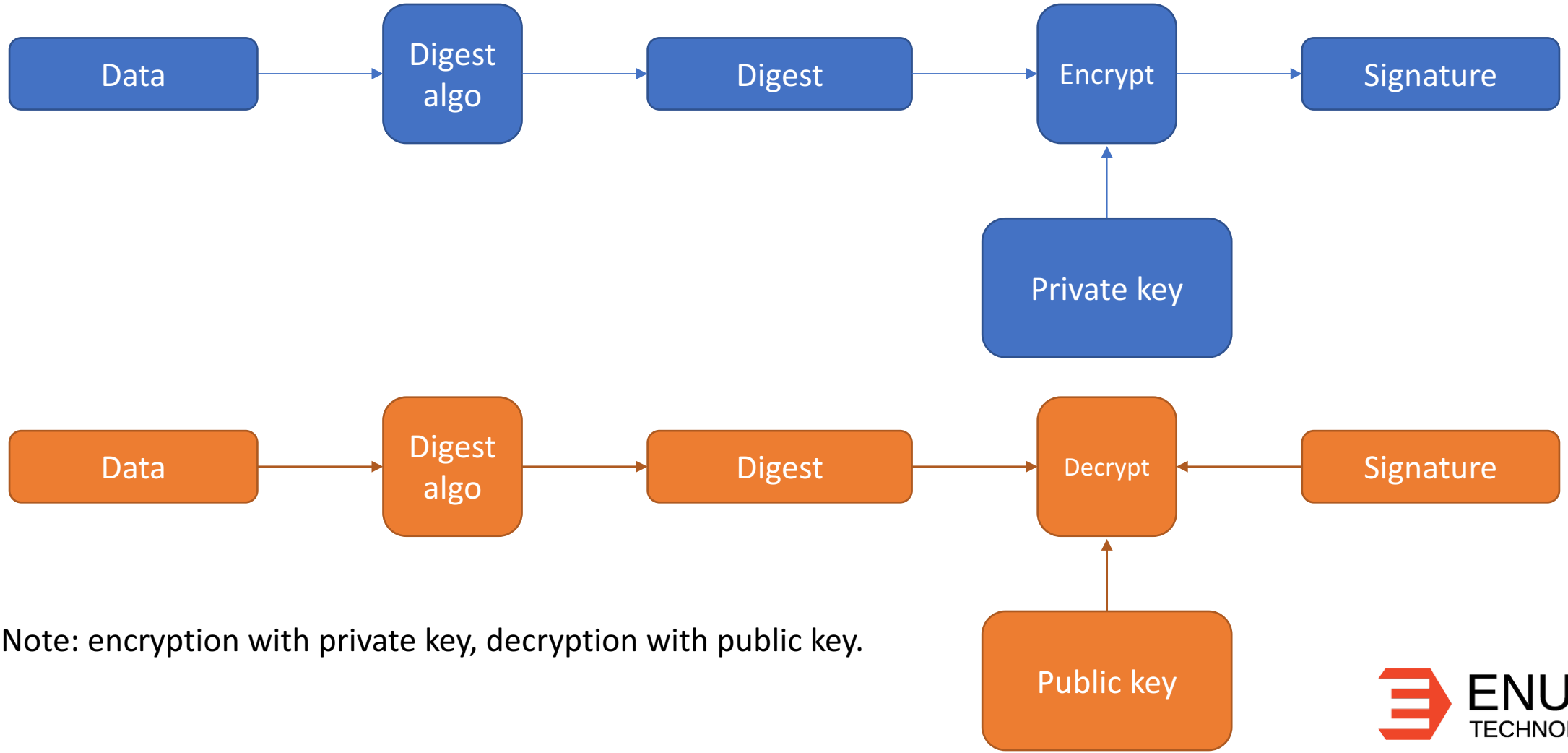
Digital Signatures : plain RSA



Note: encryption with private key, decryption with public key.

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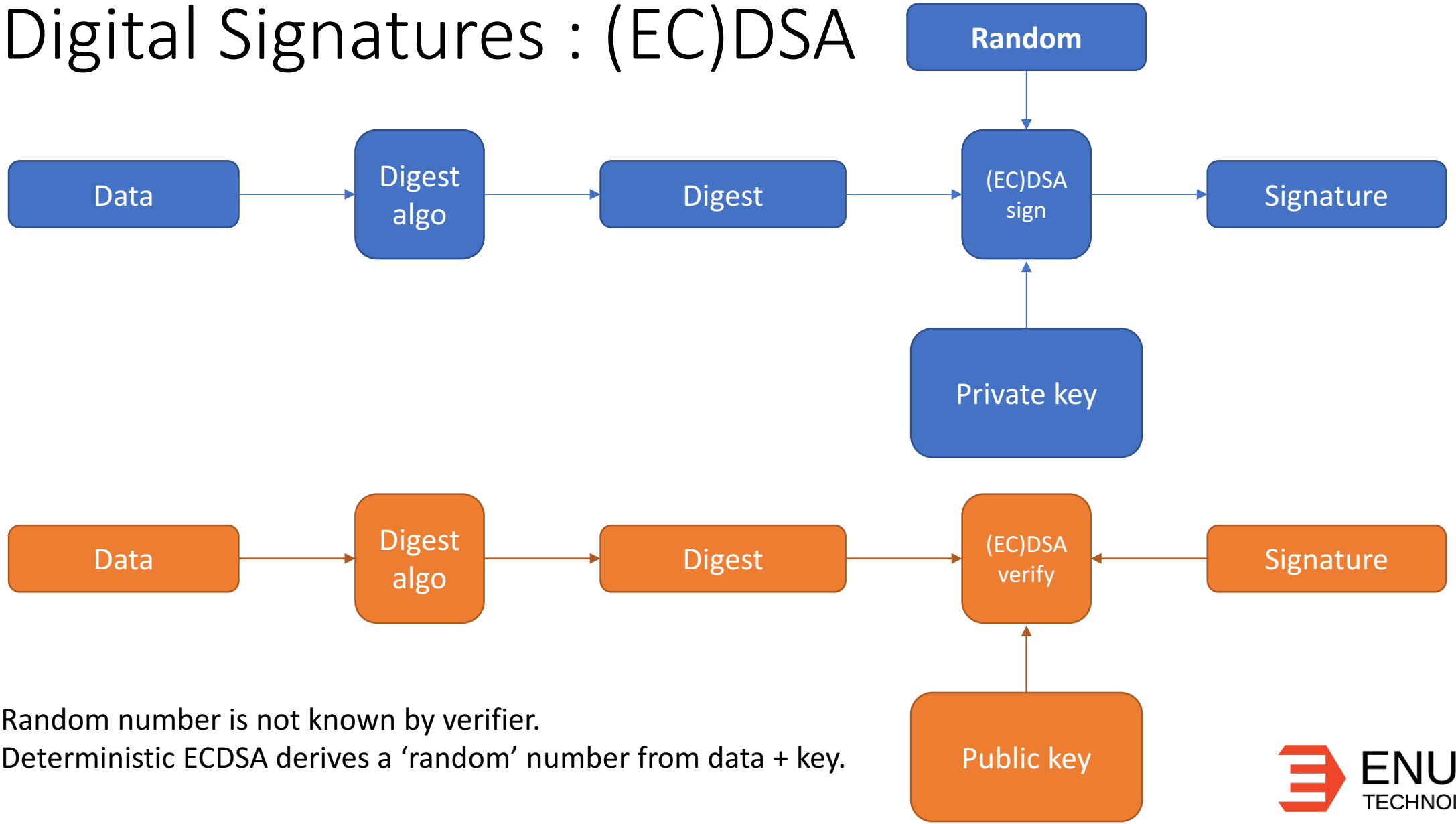
Digital Signatures : (EC)DSA



Random number is not known by verifier.
Deterministic ECDSA derives a ‘random’ number from data + key.

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Digital Signature inside Bitcoin transaction

```
000:  0100000001ac18fa31f68e5597d4d1580ec1bdea10be30a39d10dddfd41360b3
020:  f7bbc40fac00000006a473044022006d3e58f553c0605c3a663d6baa7258cd53
040:  6f3c50f4aac96c361695f82ab2017d022003ad05075cff6be0185d4dcc7581a6
060:  0634de35a33585f009ab2f0d1beb9ccbd801210374b22e7dd641b4d24c483023
080:  a275fc808c813fe89f8cb4a9c97ef0f3431afb37ffffffff0202000000000000
0A0:  001976a914a24d41cca0b9baba81ce4f43747d97e24846ca6088acee3dcd1d00
0C0:  0000001976a91444635889ad4ba11e76c14d347867c48dba4069b388ac000000
0E0:  00
```

A 256-bit ECDSA signature consists of two 256-bit DER-encoded integers.

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Attacks on Software Digital Signatures

- Bad random number generation
  - PS3
  - Android: bitcoin wallet
- Bad deterministic key generation
  - BIP032 vulnerability
- Side-channel monitoring of key generation
  - Trezor v1
- Key compromise
  - Cross-VM snooping
  - Row hammer

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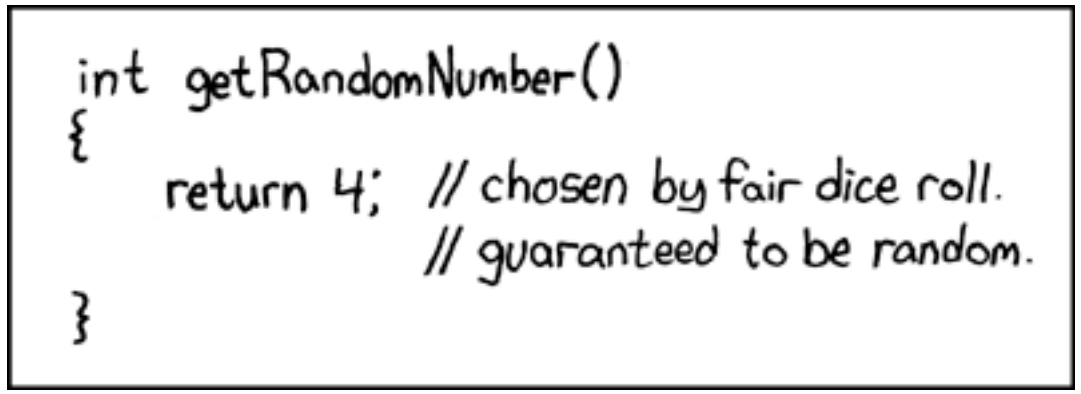
PS3 attack in a nutshell



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Crypto Hardware

- iOS Secure Enclave
- ARM Trusted Execution Environment (used by Android M and up)
- iNTEL SGX
- Atmel ECC crypto element
- Infineon Security controller
- NXP Secure authentication microcontroller
- FPGA-based
- SafeNet Luna SA (Amazon CloudHSM)
- Thales nShield (Azure Key Vault)

Hardware keys on iOS

```
var dict: [String: AnyObject] = [
    String(kSecAttrKeyType) : kSecAttrKeyTypeEC,
    String(kSecAttrKeySizeInBits) : 256 as AnyObject
]

#if !((arch(i386) || arch(x86_64)) && os(iOS) && !NO_SE)
    dict[String(kSecAttrTokenID)] = kSecAttrTokenIDSecureEnclave
#endif

let result = SecKeyGeneratePair(dict as CFDictionary, &publicKey, &privateKey)
```

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Hardware keys on Android

```
KeyPairGenerator keyPairGenerator =
    KeyPairGenerator.getInstance(KeyProperties.KEY_ALGORITHM_EC,
                                 "AndroidKeyStore");

KeyGenParameterSpec.Builder builder =
    new KeyGenParameterSpec.Builder("some key alias",
                                    KeyProperties.PURPOSE_SIGN);

keyPairGenerator.initialize(
    builder
        .setAlgorithmParameterSpec(new ECGenParameterSpec("secp256r1"))
        .setDigests(KeyProperties.DIGEST_SHA256, KeyProperties.DIGEST_NONE)
        .build());

KeyPair keyPair = keyPairGenerator.generateKeyPair();
```

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Hardware key in Azure

npm install azure -g

azure keyvault create my-vault --resource-group free-hk --location eastasia --sku premium

azure keyvault key create --vault-name my-vault --key-name MyKey --destination HSM

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Limitations of Crypto Hardware

- Key size
  - often ≤ 256 bits EC, ≤ 2048 bits RSA
- Algorithms
  - EC, SHA, ECDHE, RSA?
- Curve domain parameters
  - Secp256r1
  - usually no Secp256k1

Thank you

- Related info:

  http://blog.enuma.io/update/2016/11/01/a-tale-of-two-curves-hardware-signing-for-ethereum.html

lio@enuma.io

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