Ich will doch nur verschlüsseln...

Real world cryptography for developers

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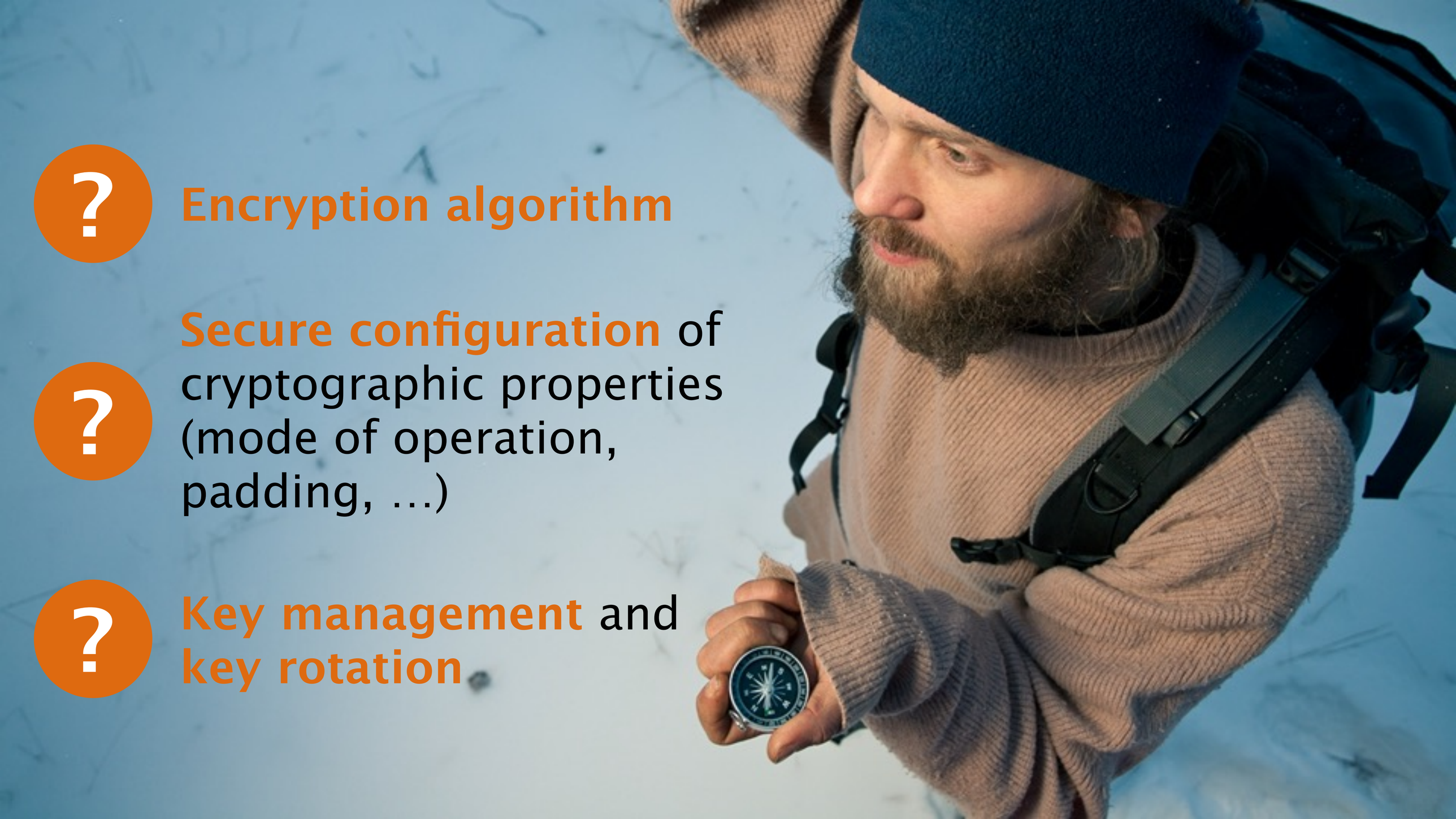
Dominik Schadow
@dschadow

bridgingIT



? **Encryption algorithm**

? **Secure configuration** of cryptographic properties (mode of operation, padding, …)

? **Key management** and **key rotation**

Out of Scope

Encryption functionality provided by/ integrated in

- Operating Systems (disk encryption)
- Databases and other data stores

Take Aways

1. A **modern (Java) crypto library** should **provide secure defaults**

2. **Crypto usage (dev)** and **key management (ops)** go hand in hand

3. **Trust the cloud?** Externalize your **key management**

Don't invent your own crypto. Just don't!

Crypto Library vs. Crypto Service

Google Tink

Multi-language - Java, Android, C++, Obj-C, Go (Python and JavaScript as early versions) and **cross-platform** open source library

Secure, easy to use, hard(er) to misuse - additional parameters are automatically and randomly initialized (all-in-one constructions)

Used in Google products like AdMob, Android Pay, and Google Android Search App

Easier Configuration by Limitation

Selected crypto algorithms (primitives)

AEAD: AES-EAX, AES-GCM, AES-CTR-HMAC, KMS Envelope, ChaCha20-Poly1305

Streaming AEAD: AES-GCM-HKDF-Streaming, AES-CTR-HMAC-Streaming

Deterministic AEAD: AES-SIV

Hybrid Encryption: ECIES with AEAD and HKDF

MAC: *HMAC-SHA2*

Digital Signatures: *ECDSA over NIST curves, Ed25519, RSA-SSA-PKCS1, RSA-SSA-PSS*

Automatic initialization of their parameters

Authenticated Encryption with Associated Data

Detects any modification on ciphertext (integrity)

Associated Data is NOT the key - optional part, **not encrypted but authenticated**, must be identical for decryption and is added as authentication tag

Heavily used in **TLS 1.3**

Exception Handling with Java and Tink

Plain Java

```
catch NoSuchPaddingException,
NoSuchAlgorithmException, KeyStoreException,
IllegalBlockSizeException, BadPaddingException,
CertificateException, InvalidKeyException,
UnrecoverableKeyException
```

Google Tink

```
catch GeneralSecurityException
```

Full or Selected Library Integration

Register the complete library

```
TinkConfig.register();
```

Register selected primitive(s) only

```
AeadConfig.register();
HybridConfig.register();
MacConfig.register();
SignatureConfig.register();
```

Keyset and KeysetHandle

Keyset is a collection of keys

- All keys in a keyset correspond to a single primitive
- One key is the primary key

KeysetHandle form a wrapper around a Keyset

- Stores key data and meta data

Instantiate a Primitive

```
KeysetHandle keysetHandle =
  KeysetHandle.generateNew(
    AeadKeyTemplates.AES128_GCM);
```

Keys are Stored as Plaintext JSON


```
"primaryKeyId": 77911481,
"key": [{
  "keyData": {
    "typeUrl": "type.googleapis.com/google.crypto.tink.AesGcmKey",
    "keyMaterialType": "SYMMETRIC",
    "value": "GhB+lIsMGzPOsRwOfYXV2rDv"
  },
  "outputPrefixType": "TINK",
  "keyId": 77911481,
  "status": "ENABLED"
}]
```

Key Rotation within the same Primitive

```
KeysetHandle keysetHandle =
  KeysetManager
    .withKeysetHandle(privateKeysetHandle)
    .rotate(HybridKeyTemplates
      .ECIES_P256_HKDF_HMAC_SHA256_AES128_GCM)
    .getKeysetHandle();
```

Keys are Organized in Keysets


```
"primaryKeyId": 448490911,
"key": [{
  "keyData": {
    "typeUrl": "type.googleapis.com/google.crypto.tink.EciesAeadHkdfPrivateKey",
    "keyMaterialType": "ASYMMETRIC_PRIVATE",
    "value": "EosBEkQKBAgCEAMSOhI4CjB0eXBlLmdvb2dsZWFwaXMuY29tL2dvb2dsZS5jcnl…"
  },
  "outputPrefixType": "TINK",
  "keyId": 976425121,
  "status": "DISABLED"
}, {
  "keyData": {
    "typeUrl": "type.googleapis.com/google.crypto.tink.EciesAeadHkdfPrivateKey",
    "keyMaterialType": "ASYMMETRIC_PRIVATE",
    "value": "EosBEkQKBAgCEAMSOhI4CjB0eXBlLmdvb2dsZWFwaXMuY29tL2dvb2dsZS5jcnlwd…"
  },
  "outputPrefixType": "TINK",
  "keyId": 448490911,
  "status": "ENABLED"
}]
```

Demo

VAULT

A tool for managing secrets.

Vault Basics

Single central store

Unsealing (opening) requires **n keys** (persons)

Generation, **storage**, and **distribution** of secrets

Various **storage backends**, static to dynamic secrets

Various **auth methods**, tokens to username/ password

Only authorized applications, policies to restrict access

Prevent sensitive data leakage - use https

Transit Secrets Engine

Cryptographic functions on data in-transit - **encryption as a service**

No data stored on server - only keys

Encrypt, decrypt *(random number generator, sign, verify, hash)* for **base64 encoded input**

Key rotation and **versioning** - disabling of old key versions

Taking a sledgehammer to crack a nut

Encryption Key Types

AES-GCM with a 256-bit AES key and a 96-bit nonce

ChaCha20-Poly1305 with a 256-bit key

2048-bit RSA key

4096-bit RSA key

```
$ vault server -dev
==> Vault server configuration:

             Api Address: http://127.0.0.1:8200
                     Cgo: disabled
         Cluster Address: https://127.0.0.1:8201
              Listener 1: tcp (addr: "127.0.0.1:8200", cluster address: "127.0.0.
1:8201", max_request_duration: "1m30s", max_request_size: "33554432", tls: "disab
led")
               Log Level: info
                   Mlock: supported: false, enabled: false
                 Storage: inmem
                 Version: Vault v1.2.1
```

```
$ vault secrets enable transit
Success! Enabled the transit secrets engine at: transit/
```

Command Line Key Generation

no key/value input

key name

```
$ vault write -f transit/keys/my-sample-key
Success! Data written to: transit/keys/my-sample-key
```

AES-GCM as default algorithm

Create encryption key

Name

my-sample-key

Type

- ✓ aes256-gcm96
- chacha20-poly1305
- ecdsa-p256
- ed25519
- rsa-2048
- rsa-4096

☐ **Enable convergent encryption**

Create encryption key | **Cancel**

Demo

Crypto in the Cloud

Cloud KMS Integration in Applications

Every(?) cloud provider offers a KMS - AWS KMS, Azure Key Vault, Google Cloud KMS

Typically **store a master key that never leaves the system**

Used to **encrypt and decrypt data stored someplace else**

Combining Tink with Key Management Systems

Tink supports the cloud KMS of Google Cloud KMS, AWS KMS, and Android Keystore

1. Create a master key in the KMS
2. Provide Tink with KMS (Cloud) credentials
3. Tell Tink where to find the master key

Master Key and AwsKmsClient

```
String MASTER_KEY_URI = "aws-kms://arn:aws:kms:…";

KeysetHandle keysetHandle =
  KeysetHandle.generateNew(
    HybridKeyTemplates.
    ECIES_P256_HKDF_HMAC_SHA256_AES128_GCM);

keysetHandle.write(
  JsonKeysetWriter.withFile(keysetFile),
  new AwsKmsClient()
   .withDefaultCredentials().getAead(MASTER_KEY_URI));
```

Demo

Summary

Use established libraries like **Google Tink** for your custom development (and **integrate a Cloud KMS**)

Use **Vault Transit Backend when already available in your environment**

Development is only part of the story - crypto requires **DevOps for real world security**

bridging IT

Marienstr. 17
70178 Stuttgart

dominik.schadow@bridging-it.de
www.bridging-it.de

Blog blog.dominikschadow.de
Twitter @dschadow

Google Tink Demo Project
https://github.com/dschadow/JavaSecurity
Vault Demo Project
https://github.com/dschadow/CloudSecurity
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Vault Transit Secrets Engine
https://www.vaultproject.io/docs/secrets/transit/index.html
Pictures
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