Mobile Application Development
Sign Your App

Waterford Institute of Technology

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Sign your app

Learning objectives

An overview of:

- Symmetric key encryption
- Public key encryption
- Cryptographic hash function
- Exchange secret key in public channel
- Review programming module crypto
- Certificates
- Signing app
- Key storage and security
- Secure shell (SSH)

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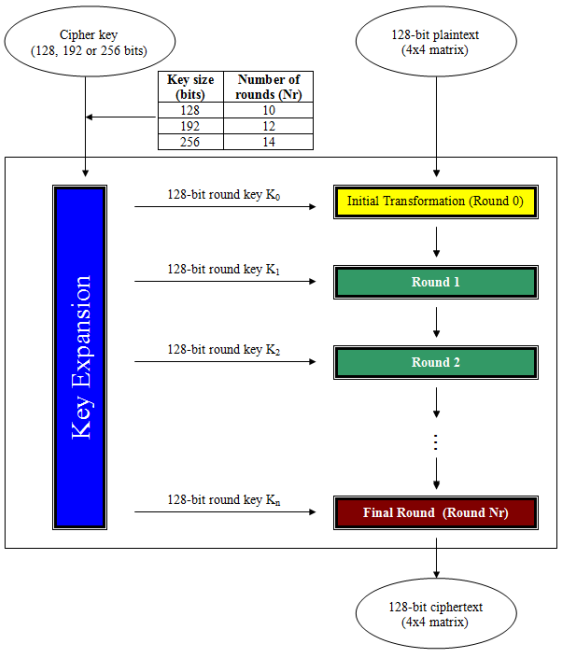
Learning objectives

Abstraction: focus on details appropriate target audience

- High level: *ssh mike@192.168.61.8*
- Intermediate: $c = m \oplus k$
- Low: $D(k, c') = m_1 \oplus 1$



Sign your App

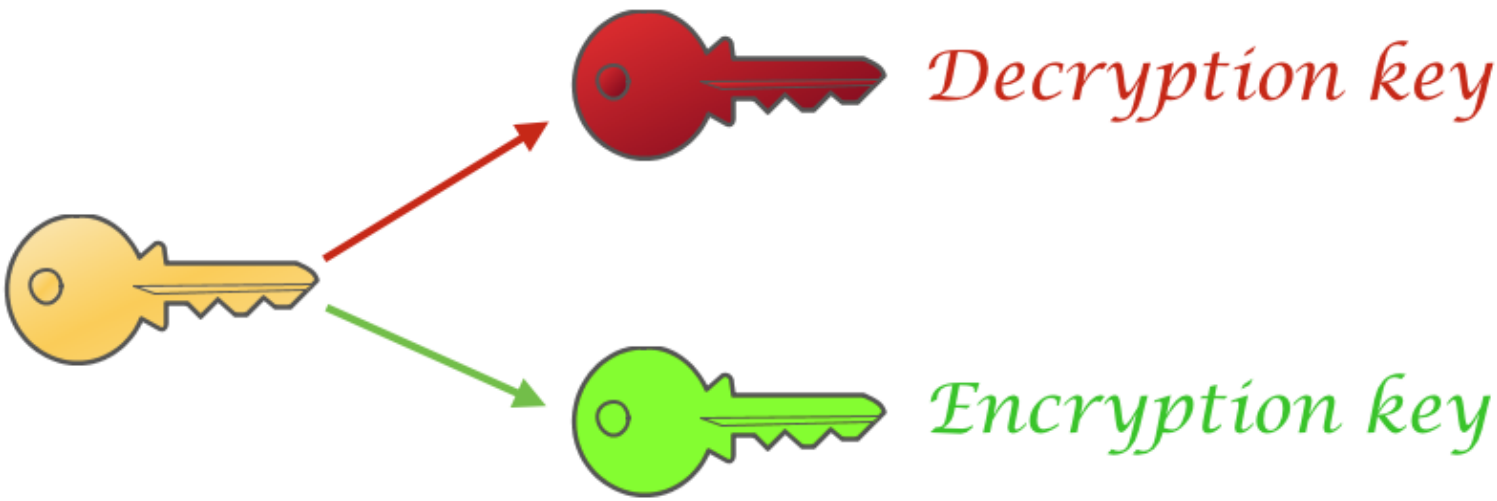
Android Studio

Android Studio APK Signing

Sign your App

Public Key Encryption

- Two related keys used.
- A private (secret) key (SK) used to decrypt.
- A public key (PK) used to encrypt.
- Keys have inverse functionality.
  - Encrypt with PK => decrypt with SK.
  - Sign (encrypt) with SK => verify (decrypt) with PK.



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Certificates and Keystores

Public-key certificate

- Also known as:
  - Digital certificate
  - Identity certificate
- Comprises:
  - Public key
  - Meta data
- Certificate owner:
  - Uses private (secret) key

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Certificates and Keystores

- Android studio includes signing tool.
- Configurable auto or manual.
- App may also be signed using commandline tools.
- Attaches digital certificate to APK.
- Certificate acts as digital fingerprint or signature.
- Uniquely associates APK to author and its private key.
- Verifies future app updates authentic.
- Same certificate must be used during entire app life.

Sign your app

Digital Signature Scheme

Digital Signature Scheme comprises 3 algorithms:

- Public-private key-pair generator.
- Signing algorithm:
  - Input: message + private key.
  - Output: signature.
- Signature verifying algorithm:
  - Input: message + public key + signature.
  - Output: message authentic? Yes:No.

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Digital Signature Scheme

Android implementation (v1):

- Up to and including Marshmallow.
- Uses standard Java Development Kit (JDK) tools:
  - *jarsigner* : signs message.
  - *jarsigner* : verifies authenticity of message.

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Digital Signature Scheme

Android implementation (v2):

- Applies to Nougat (7.0).
- New app signing scheme.
- Recommended but not mandatory.
  - APK hashed and signed.
  - Resulting *APK Signing Block* inserted in APK.
  - Backward compatible.

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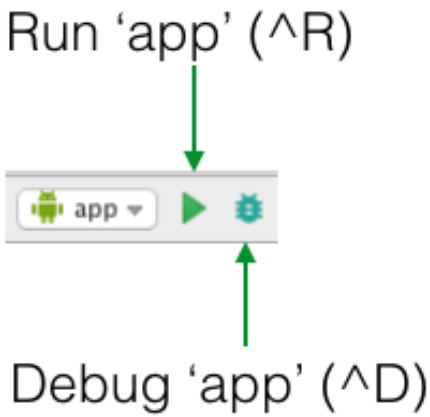
Run and build from Android Studio IDE

- Uses **debug** version apk.
- Auto signs apk with debug certificate.
- Debug cert stored in debug keystore.
- All signing data auto genererated.
- Debug unacceptable Google Play Store.



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Certificates and Keystores - Release build

- Android Studio generates keystore.
- On signing, use keystore and private key.
- Individually password protect store and private keys.
- Consider using password manager.
- Loss of passwords or keys potentially catastrophic.

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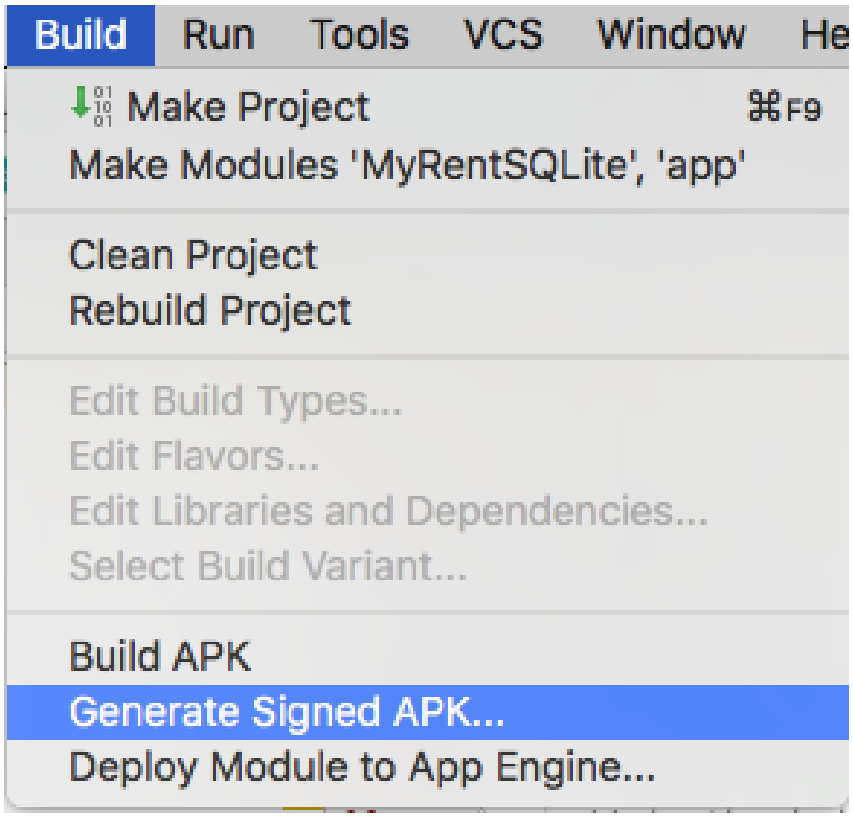
Certificate usage

- Sign all your APKs with same cert.
  - Throughout entire app lifespan.
- Facilitates upgrades.
  - Avoids loss installed client base
- Takes advantage of signature-based permissions policy.
  - Apps can share code and data securely.
- Facilitates modularization.
  - Multiple apps runnable as one in same process.

Sign your app

Manually using Android Studio



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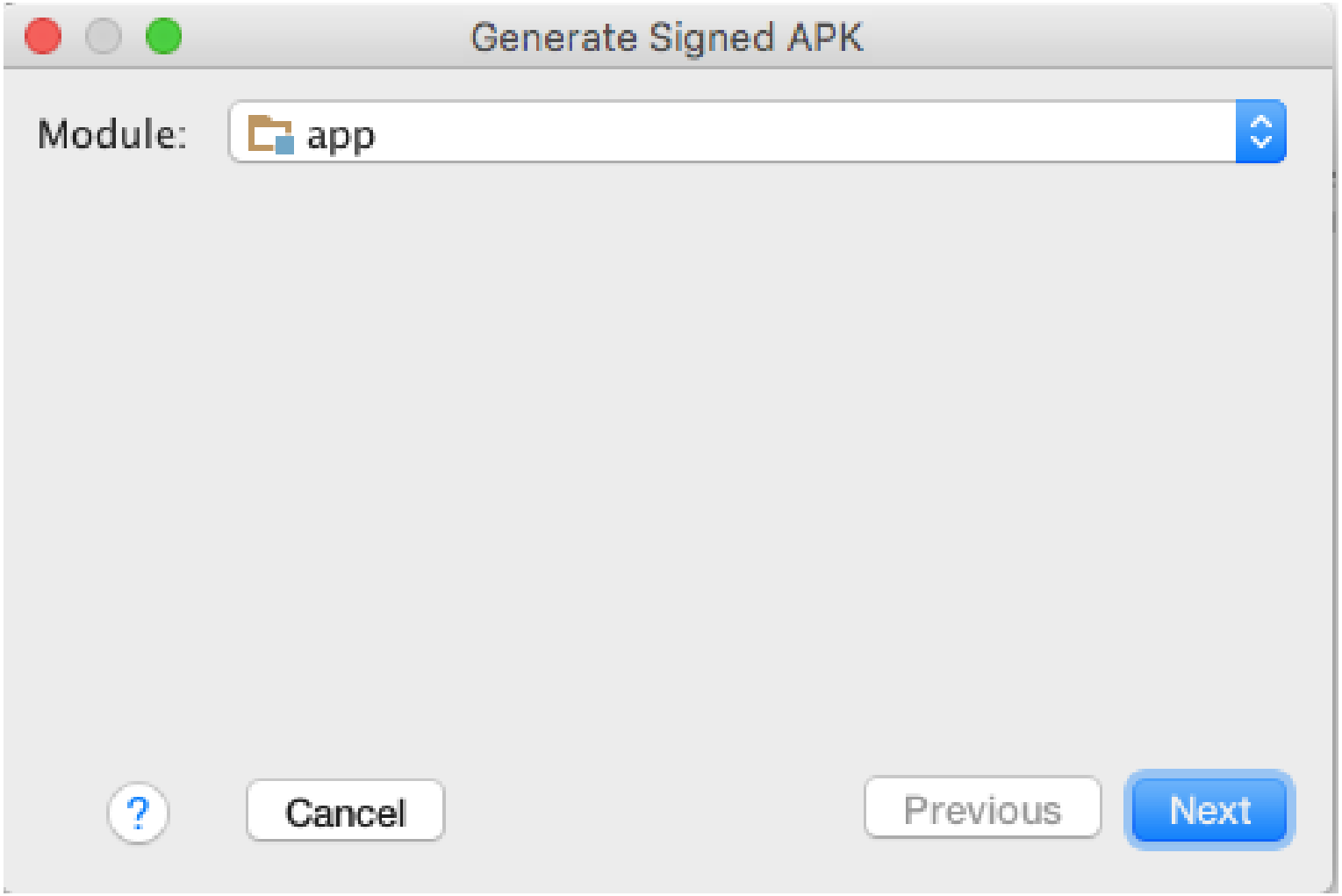

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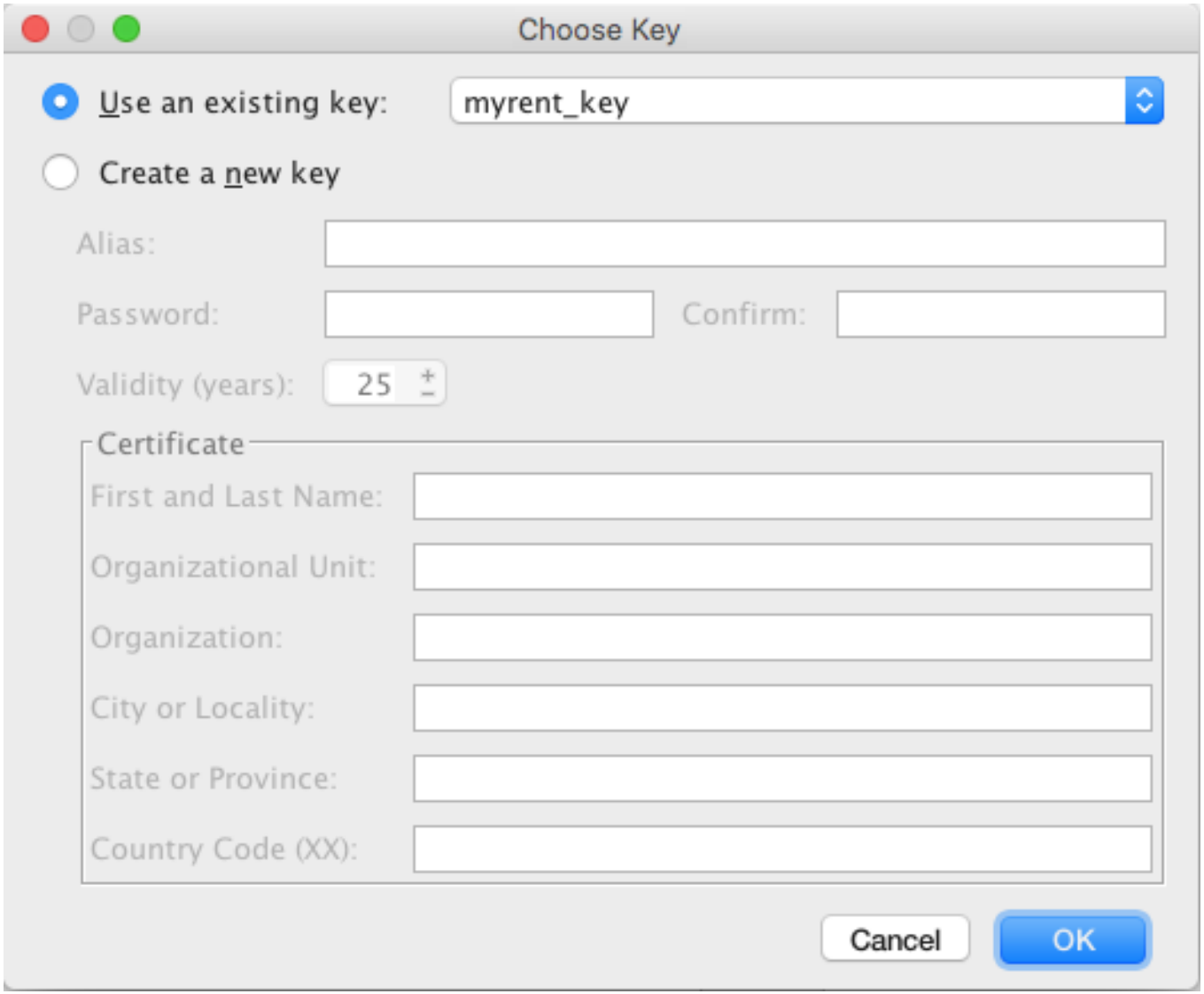

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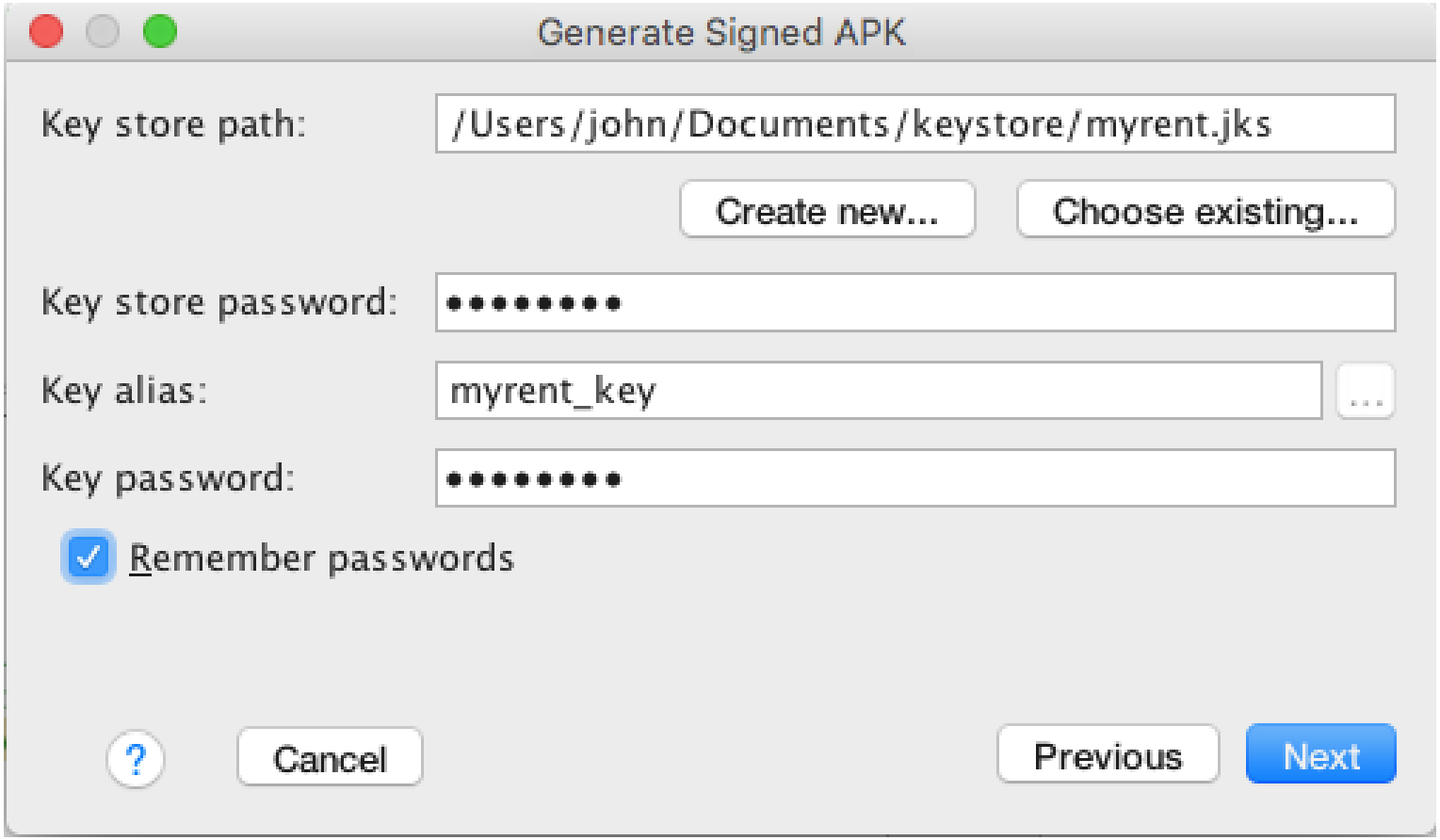

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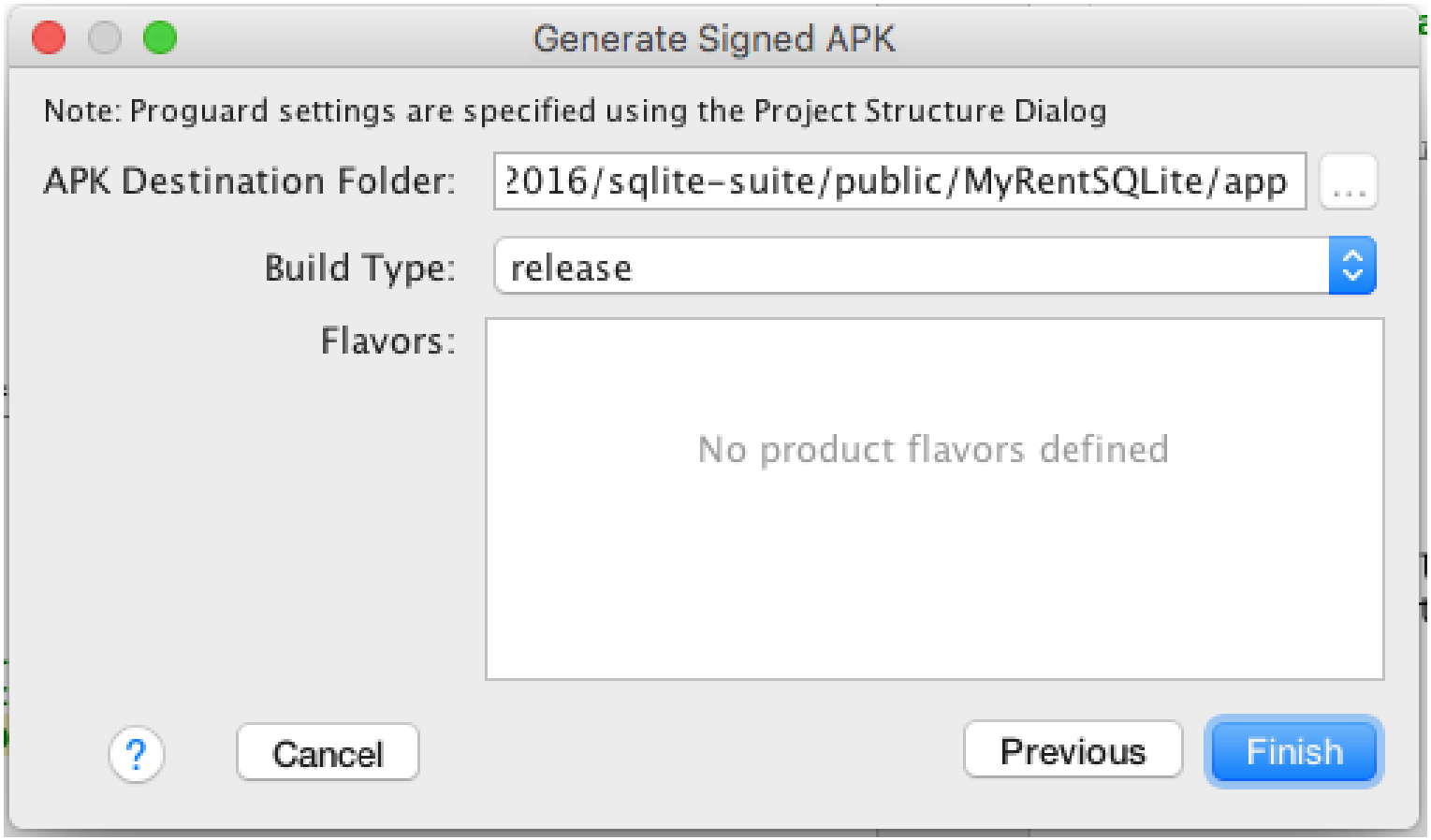

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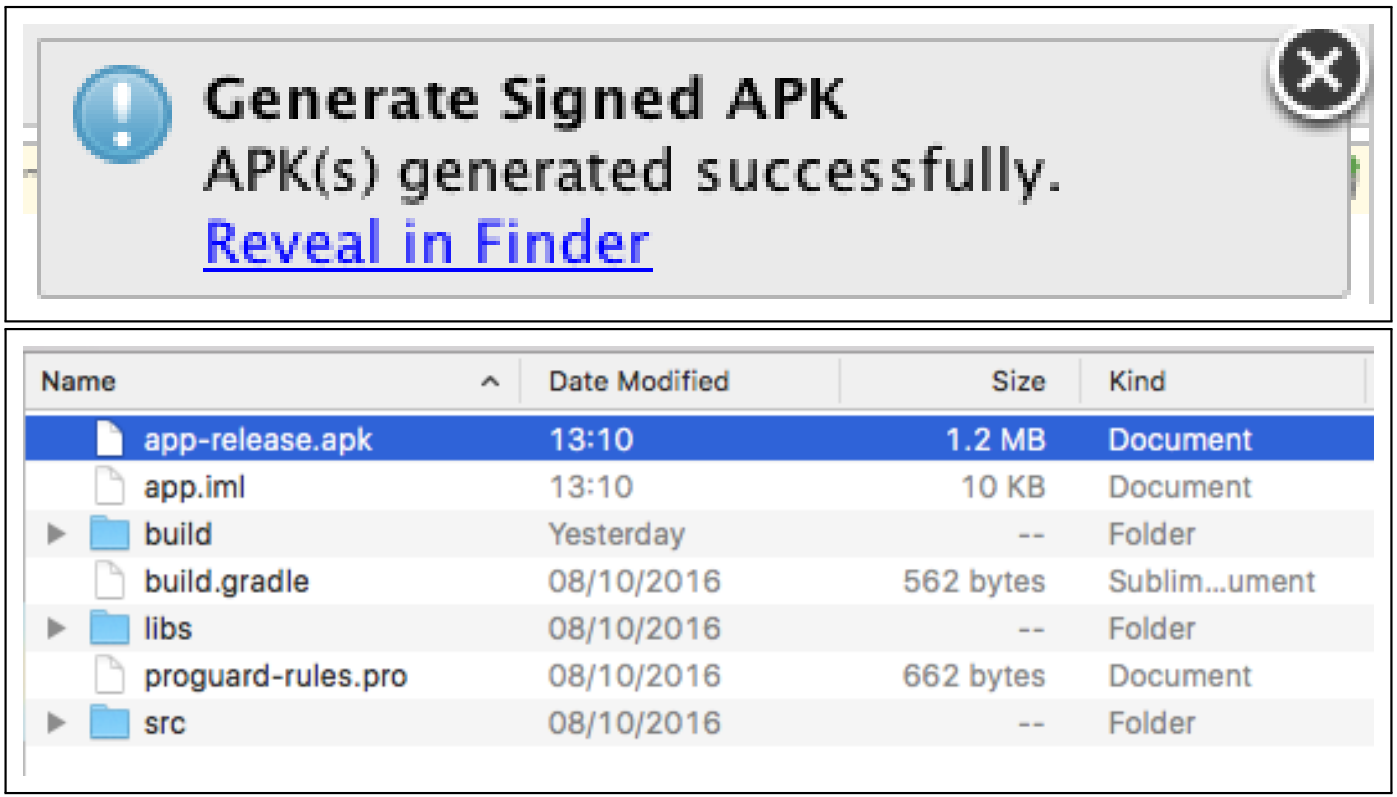

Key store and private keys

Password management

- Passwords - critically important to:
  - Retain securely,
  - Retain indefinitely.
- Consider using password manager.
- Password Safe (Windows): https://pwsafe.org/
- Gorilla (Cross platform): http://bit.ly/2elPsav
- pwSafe (Mac & iOS): https://pwsafe.info/

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Digital Signature

- Electronic analogue of physical signature
- Binds document & identity
- Not easily forged
- Various digital signature schemes:
  - Rivest, Shamir, Adleman (RSA)
  - Digital Signature Standard (DSS)

Sign your app

Digital Certificate

- Electronic document that can prove ownership.
- Pair of associated electronic keys used.
- Private key and public key.
- Signing tool attaches certificate to apk.

Sign your app

Digital Certificate

- Signed apk uniquely associated with signing author.
- Prevents forgery.
- Ensures any updates originate from signing author.

Supporting cryptograpic technology

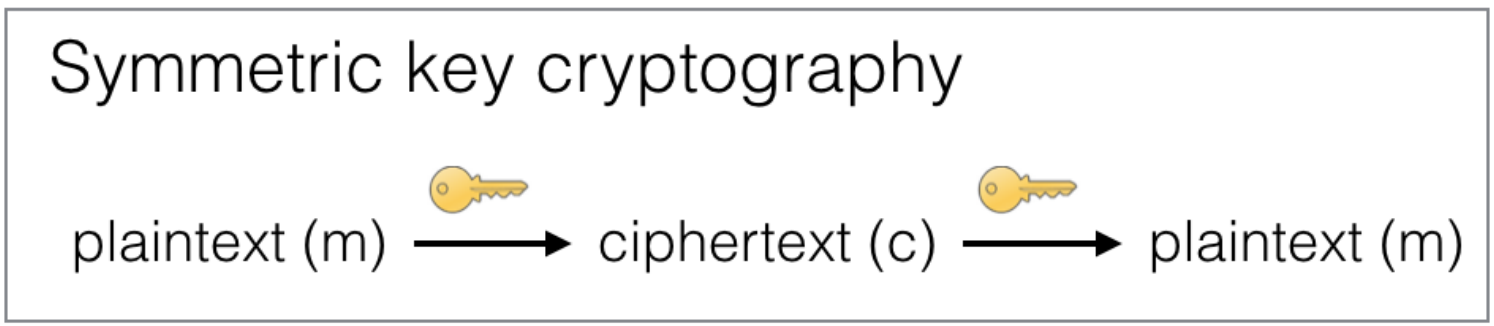
A brief exploration

Basics of Cryptographic Technology

Supporting cryptograpic technology

Three types cryptography

Single key used for both encryption and decryption.



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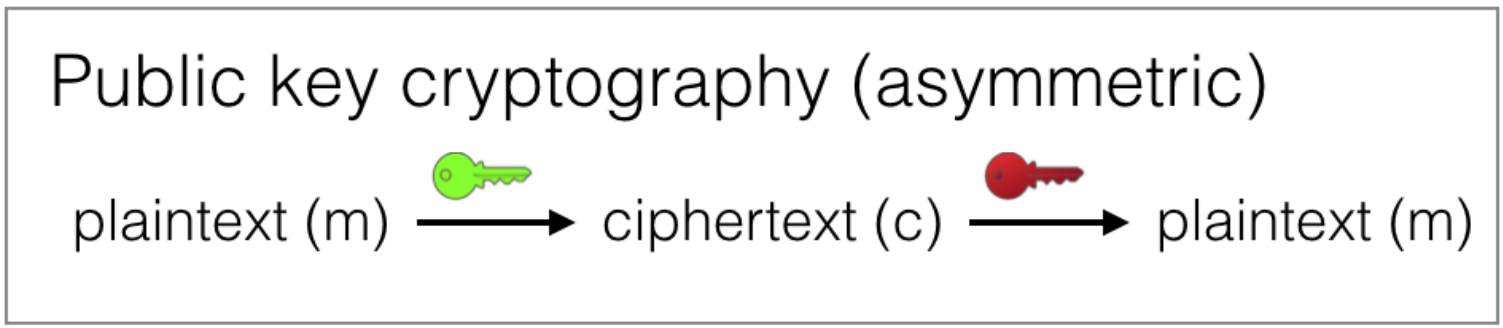
Three types cryptography

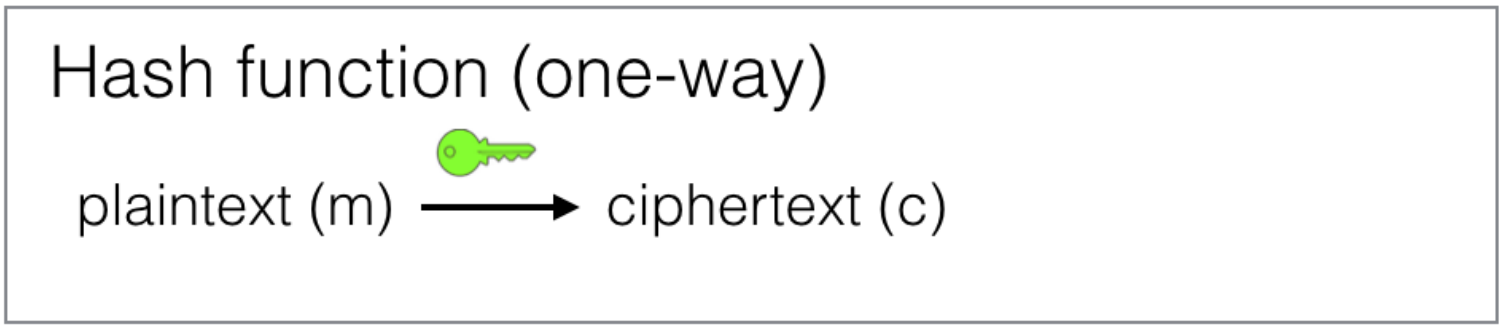
Key pair: secret and public.



Supporting cryptograpic technology

Three types cryptography

Public cryptographic hash function used. No key - plaintext not recoverable.



Supporting cryptograpic technology

Cryptographic hash function

- Uses include digital signatures, message authentication.
- Hash function maps any-size data to fixed-size data.
- Function output: hash values, codes, sums or hashes.
- Also input: message; output (message) digest.
- Collision-resistant: 2 inputs same output hard to find.
- Output does not leak input information.
- Output looks random.
- Small input change - large output change.

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Public key cryptography

Cryptographic system that:

- Uses associated pair of keys - public & private.
- Public key may be distributed widely.
- Private key should be kept secure by owner.

Sign your app

Public key cryptography

Document encrypted using public key:

- Use private key to decrypt.

Document encrypted using private key:

- Use public key to decrypt.
- This is essence of digital signing.

Supporting cryptograpic technology

Encountered to date in programming module

- Caesar cipher
- Vigenere cipher
- One-time pad (OTP)

Supporting cryptograpic technology

Encountered to date in course

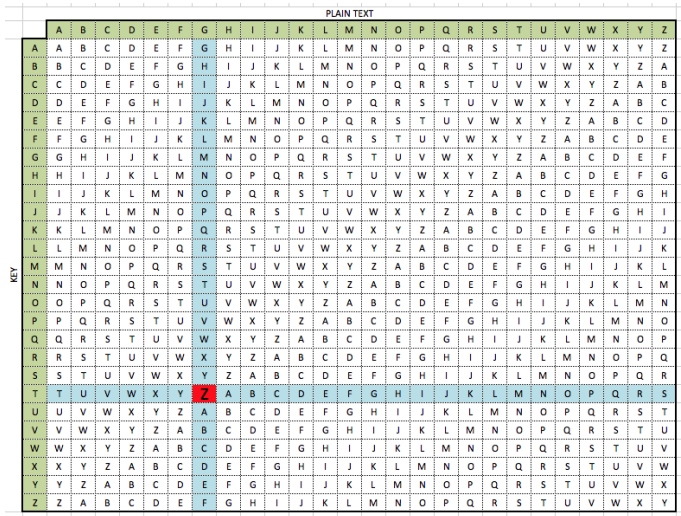
Caesar cipher

- Message text or plain text
- Cipher text: encrypted plain text
- Encrypt: shift plain text character
- Example: shift by 3 thus A becomes D

Vigenere Cipher

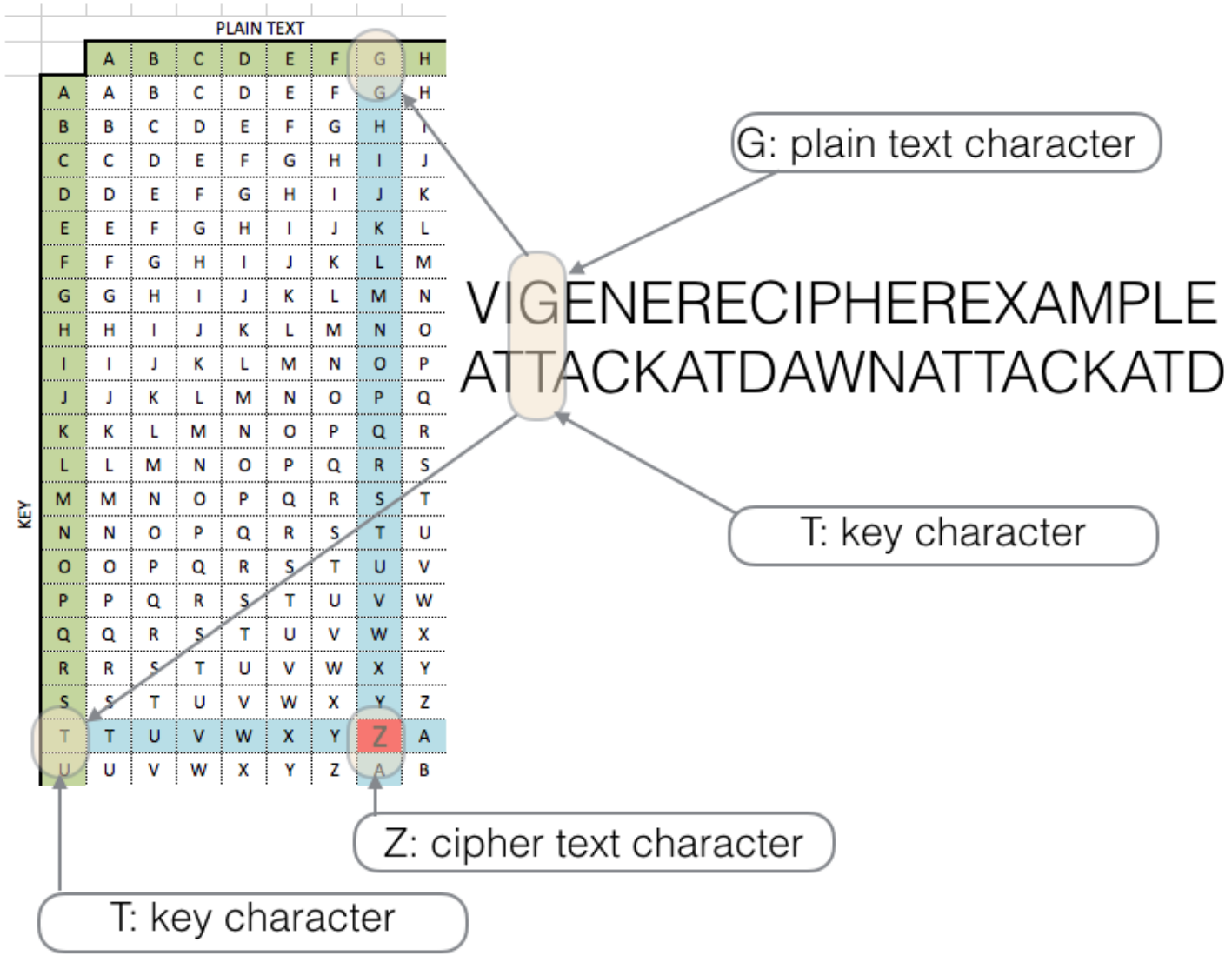
Key length matches plain text

- Plain text
  - VIGENERECIPHEREXAMPLE
- Key same length plaintext
  - ATTACKATDAWNATTACKATD



Vigenere Cipher

Encryption - Decryption



Supporting cryptograpic technology

Encountered to date in course

Potentially perfect secrecy - but practical difficulties.

- One-time pad (OTP)

One Time Pad

Key same length as plaintext

Exclusive OR denoted by $\oplus$.

- m denotes plaintext or message text
- k denotes key
- c denotes the cipher text or encrypted message
- $c = m \oplus k$

a	b	a $\oplus$ b
0	0	0
0	1	1
1	0	1
1	1	0

m	0	1	1	0	1	1
k	1	0	1	1	0	0
c	1	1	0	1	1	1

One Time Pad

Key same length as plaintext

Observe from table:

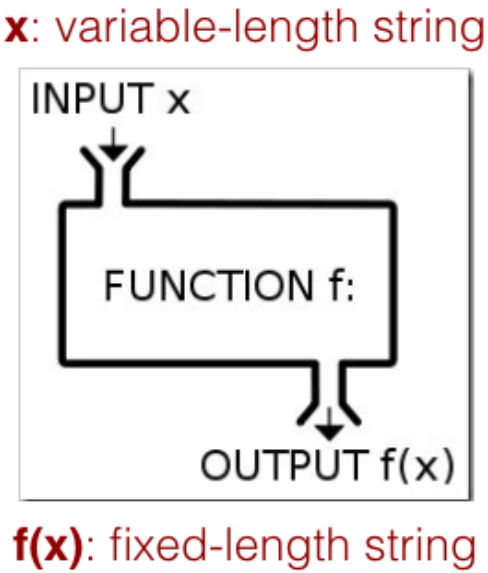
- $c = m \oplus k$
- $m = c \oplus k$

m	0	1	1	0	1	1
k	1	0	1	1	0	0
c	1	1	0	1	1	1
$c \oplus k$	0	1	1	0	1	1

Hashing

What are hashes & how are they generated?

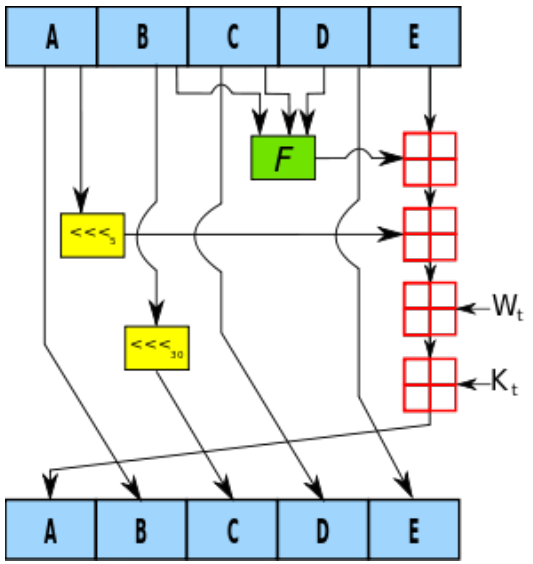
- What is a hash?
  - A fixed-length string.
  - The output from a function.
  - Known as hash function.
  - Whose input is a string of any length.



Hashing example

Git versioning system uses SHA-1 has function.

- Git uses SHA-1 hash function.
  - Purpose: ensure consistency.
  - Input: any number of bytes.
  - Output: 20-bytes.



SHA-1 hashing examples

Observe differences between inputs and outputs

ICTSkills-2015

c83007996185ec1269ae9d1e78ef12d51ac0b078

ICTSkills-2016

33f87c1b7e03bc33b34e62313a638123260ca0b0

Hash algorithm

The internals of a hash function

- Hash algorithm
  - Algorithm: series of computations.
  - Producing solution to problem.
  - Hash algorithm: the internals of hash function.

Hashes

What are they used for?

- Hashes are used:
  - To ensure data & message integrity.
  - To validate passwords.
  - In signing Android APKs.

Hashing

Hash function properties

- One-way functions.
  - Easy to compute output given an input.
  - Difficult to compute input given output.
- Small input variation.
- Result: large output variation.

Creating shared secret key

Diffie-Hellman key exchange

Diffie-Hellman

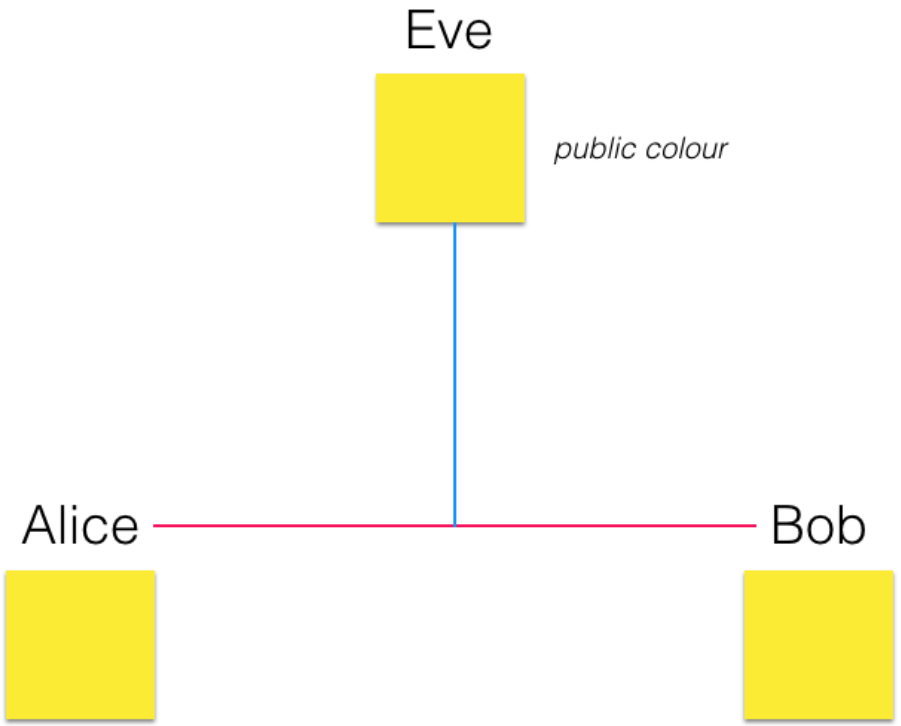
Creating shared secret key

Diffie-Hellman key exchange

- Securely exchange cryptographic keys over public channel
- PK crypto envisaged by James Ellis & mathematically proven by Clifford Cocks in GCHQ (1973).
- Malcolm Williamson in attempting to disprove PK discovered secure key exchange (1973).
- Immediately classified but made public in 1997.
- Independently discovered by Whitfield Diffie & Martin Hellman (1976).

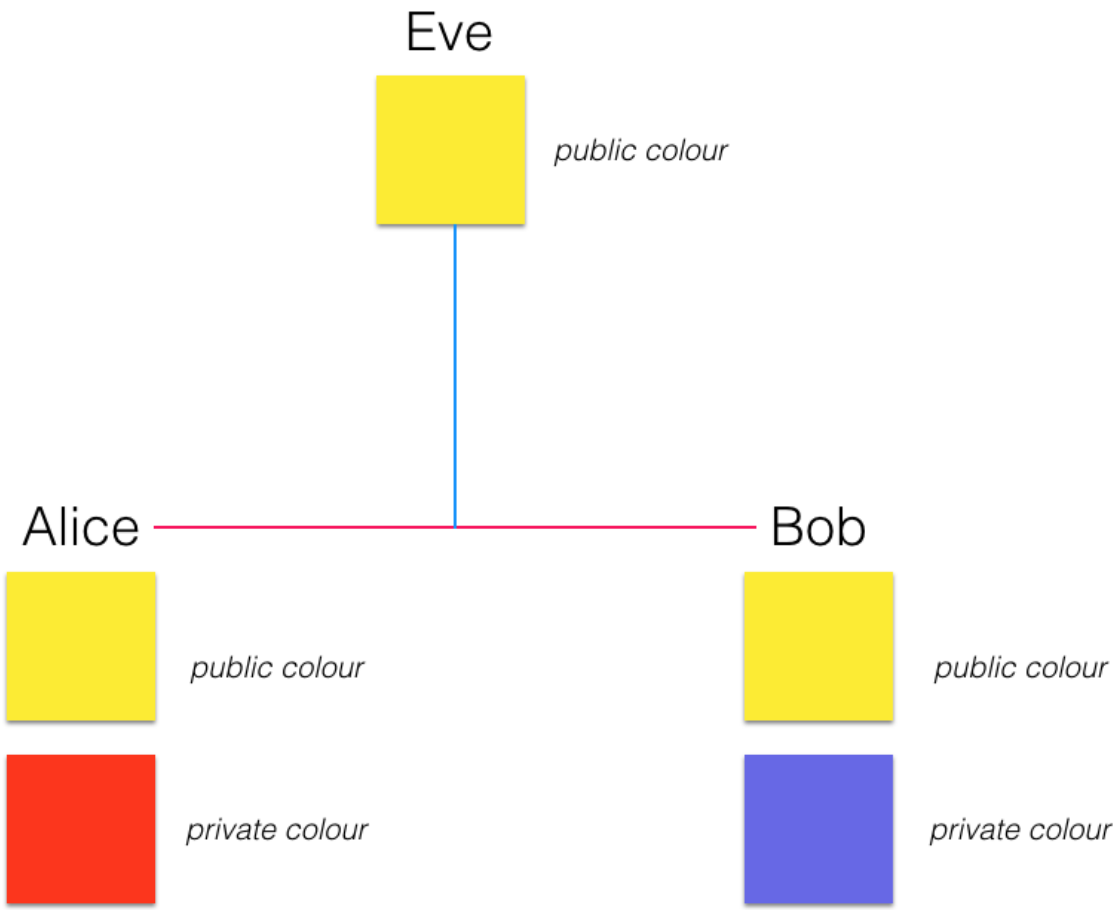
Key exchange explained using colours

A random colour published



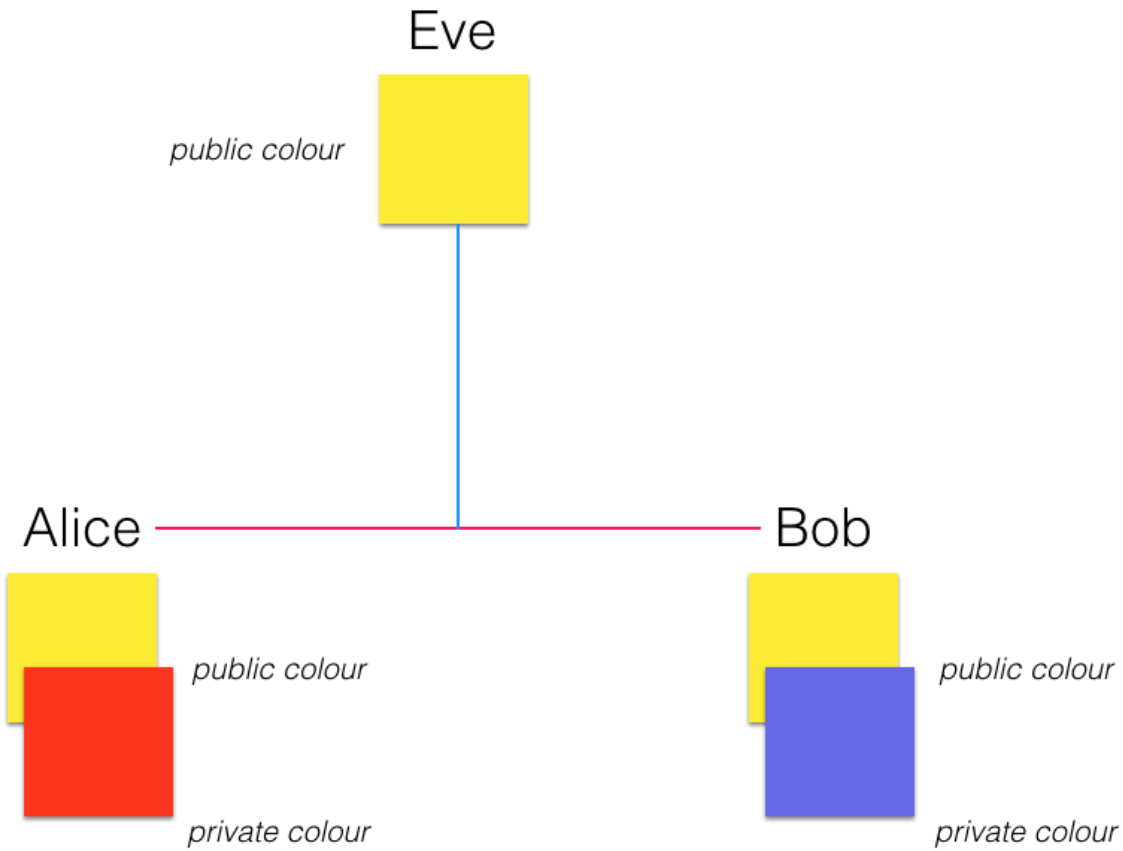
key exchange

Alice & Bob each randomly select a secret colour



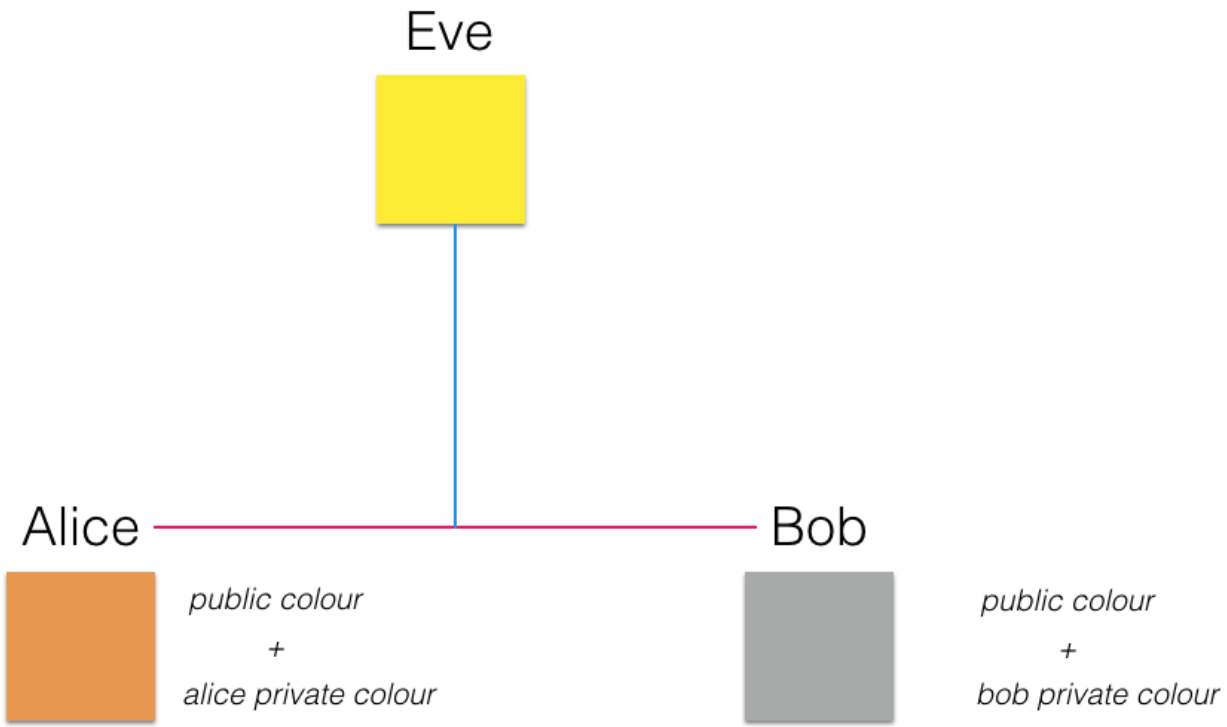
Key exchange

Alice & Bob mix public colour and secret colour - this is **easy**



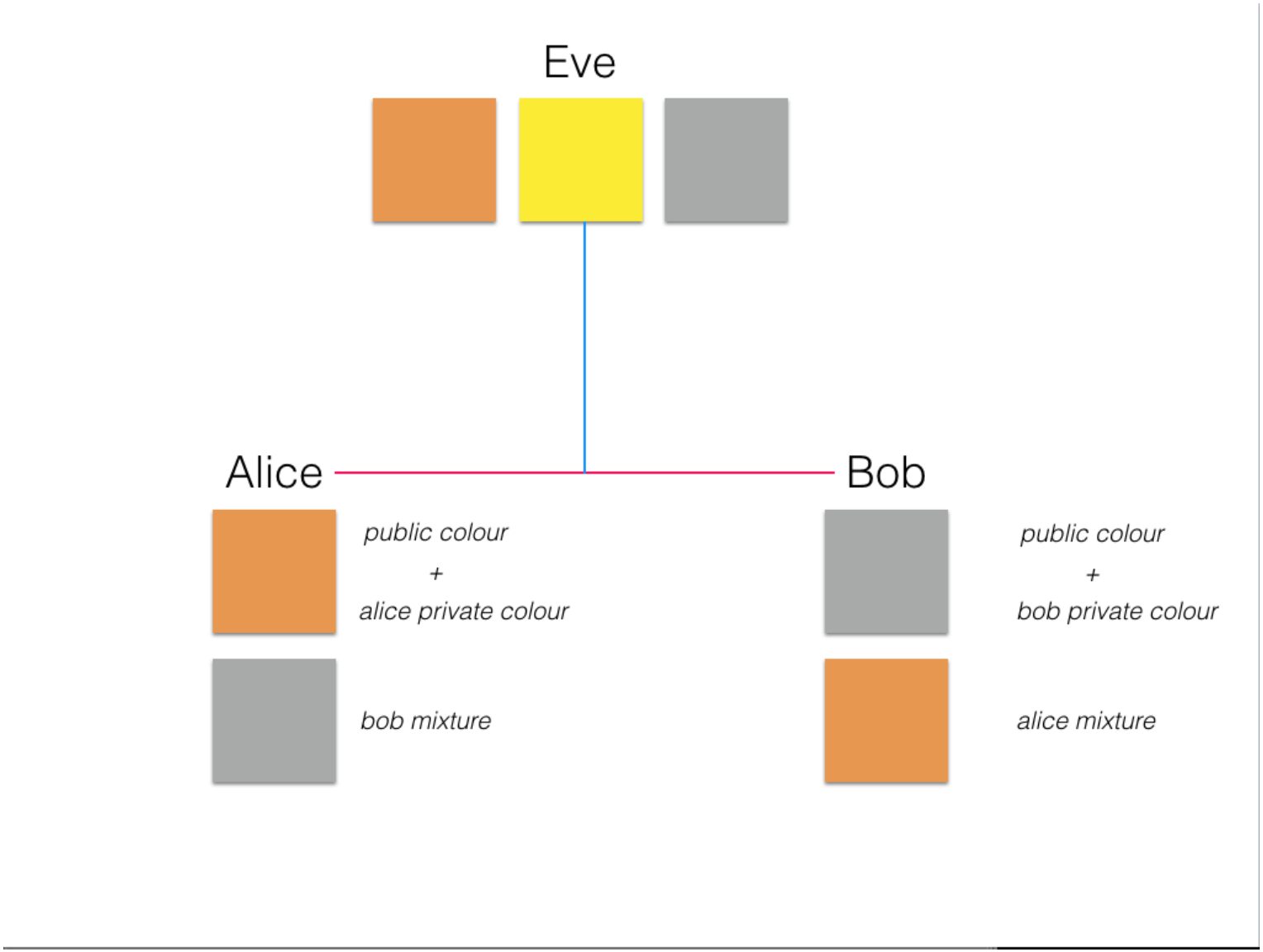
Key exchange

Alice's & Bob's mixed colours - finding original colours is is **hard**



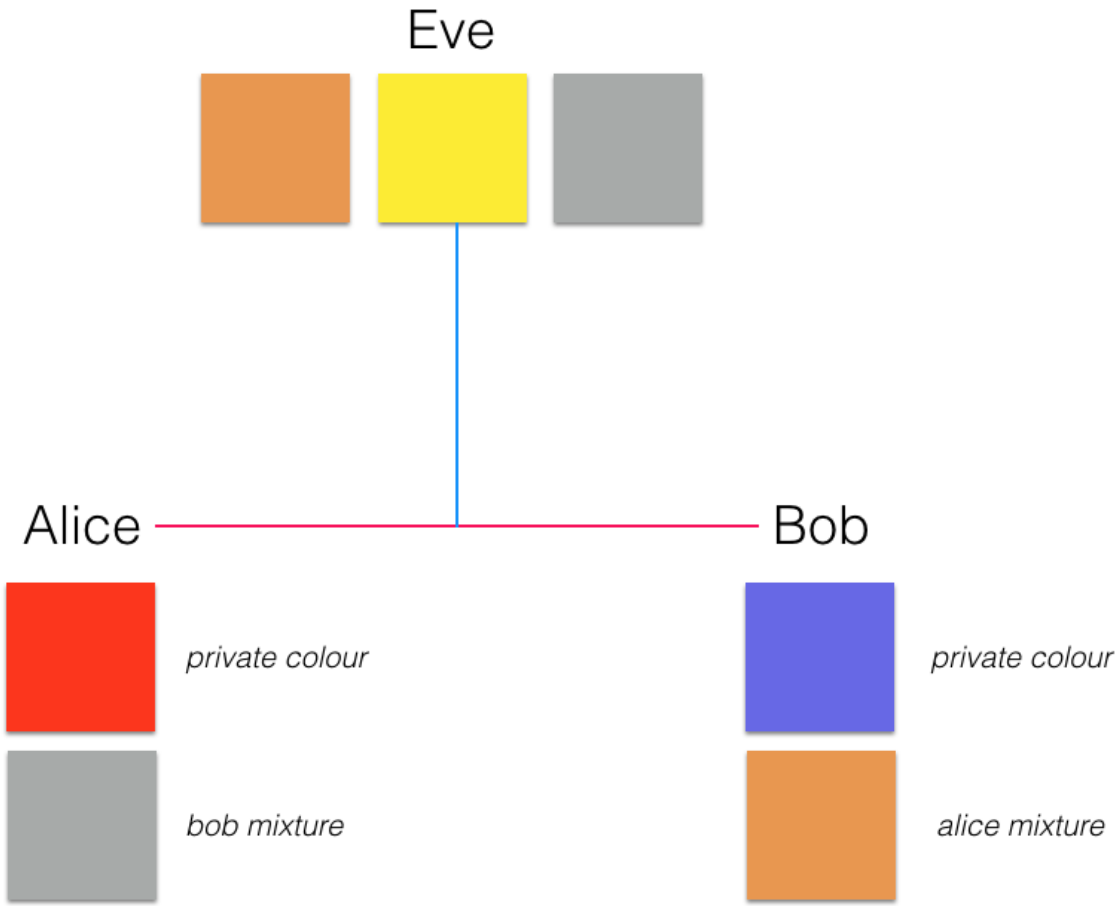
Key exchange

Alice sends Bob her mixed colour - Bob sends Alice his mixed colour



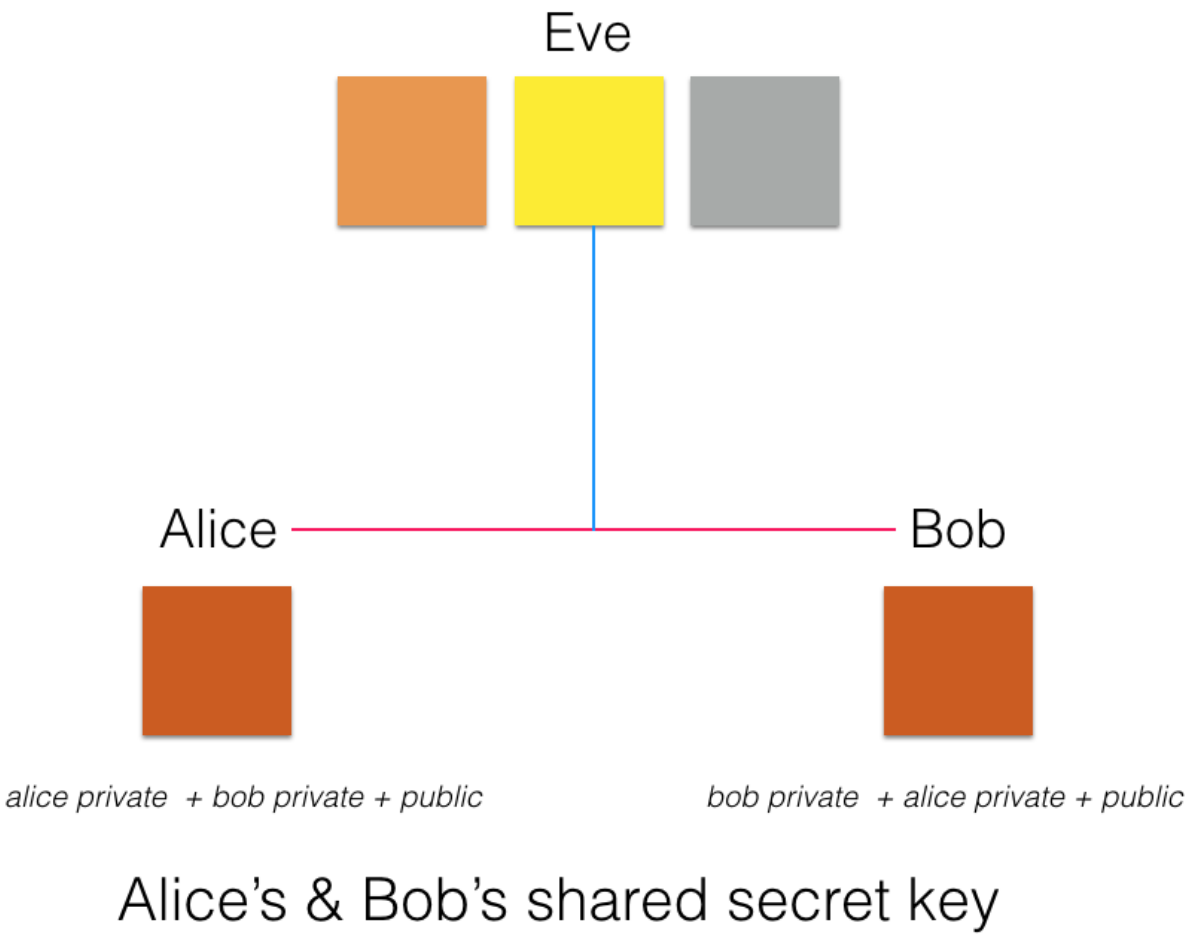
Key exchange

Alice & Bob each add private colour to mixed colors



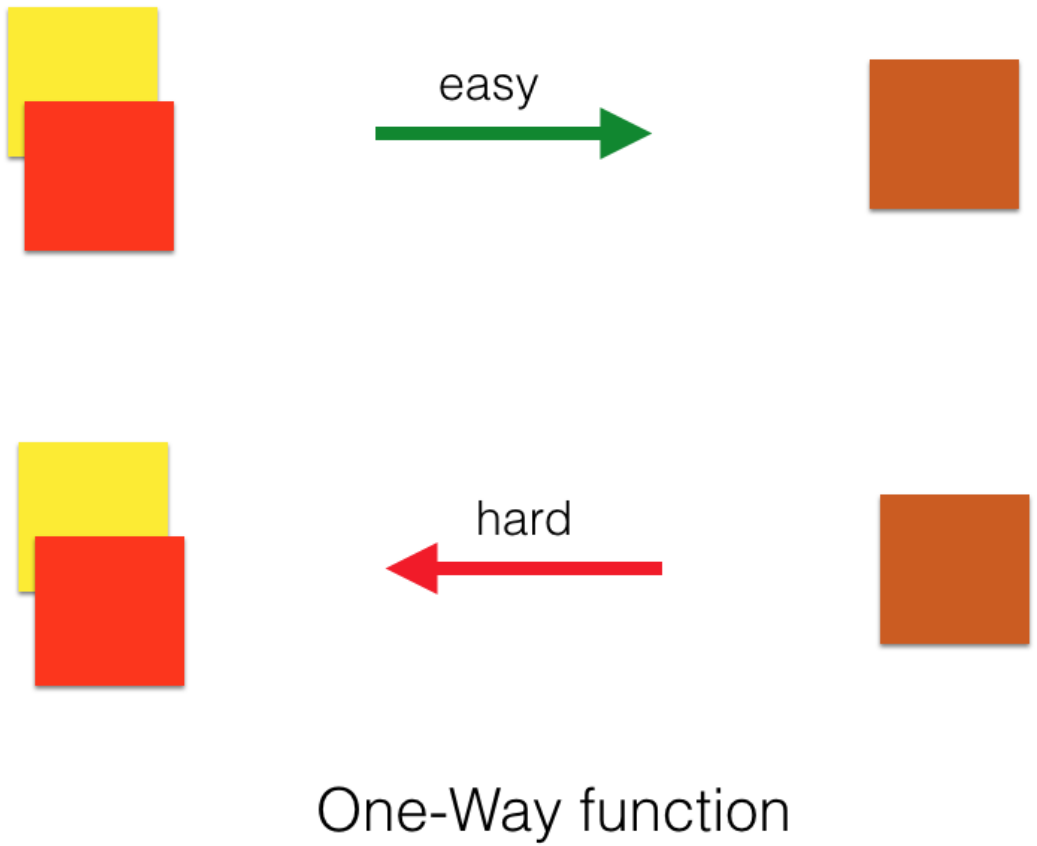
Key exchange

The two final mixtures are exactly the same colour - this is shared secret key



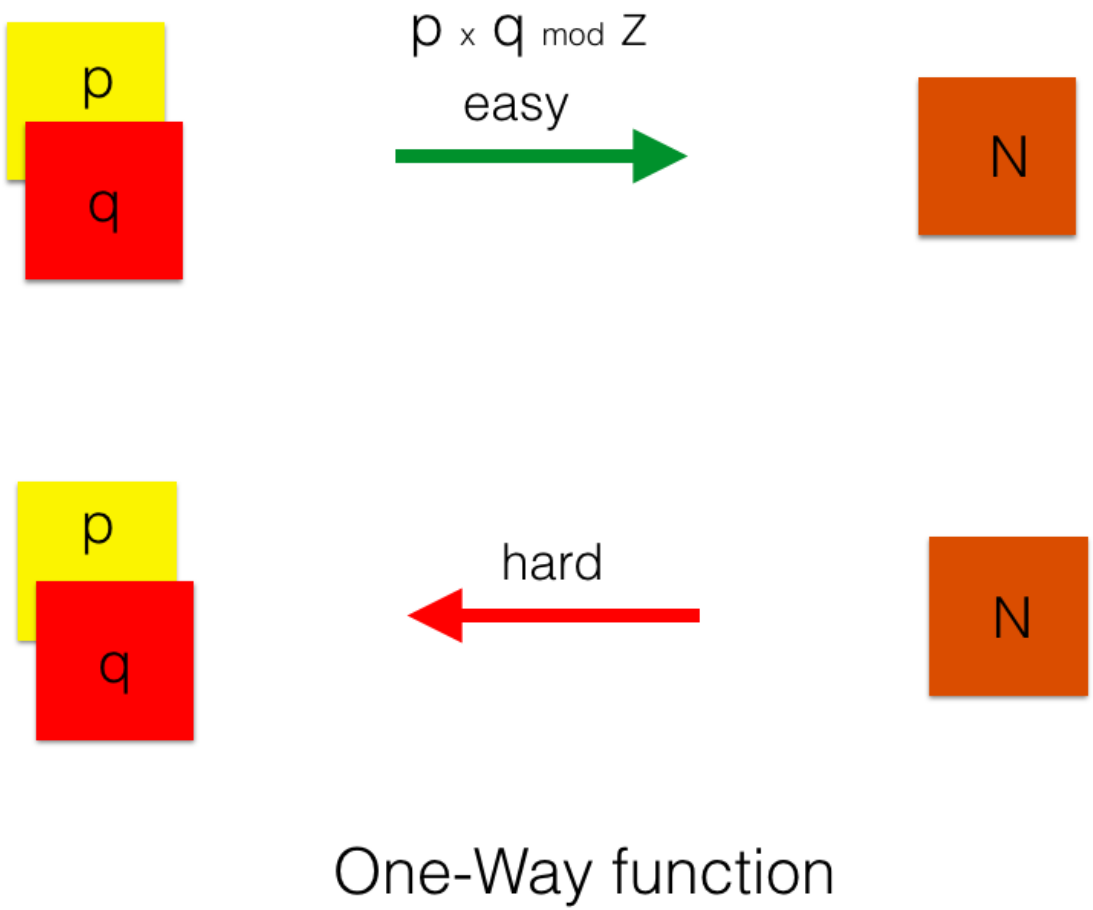
Key Exchange

Uses One-Way Function



Key Exchange

Uses One-Way Function



One-Way function

Public Key Cryptography

Public-private key pair

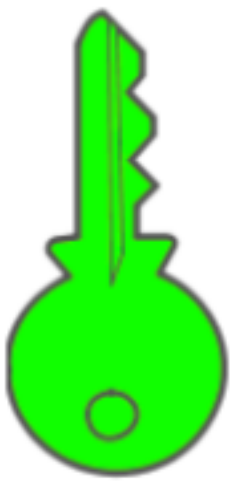
$\mathcal{RSA}$

RSA Encryption

public-private key pair

Alice:

- Creates lock & key
- Key is private.
- Kept securely.
- Lock is public.



RSA Encryption

public-private key pair

Alice:

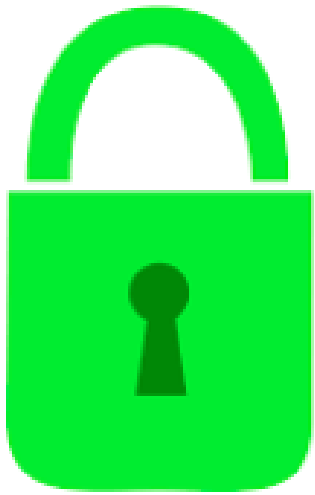
- Sends open lock to Bob.
- Could send same lock multiple people.

RSA Encryption

public-private key pair

Bob:

- Locks message.
- Returns to Alice.

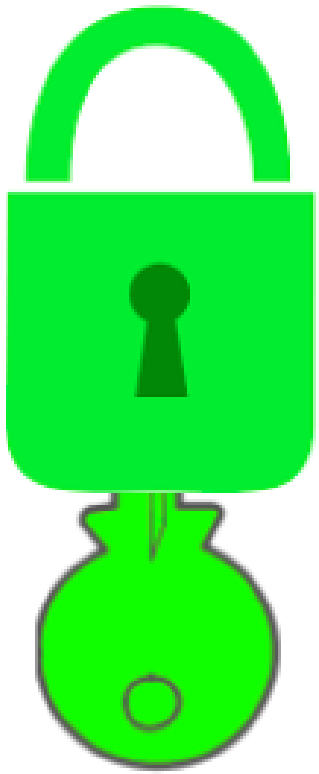


RSA Encryption

public-private key pair

Alice:

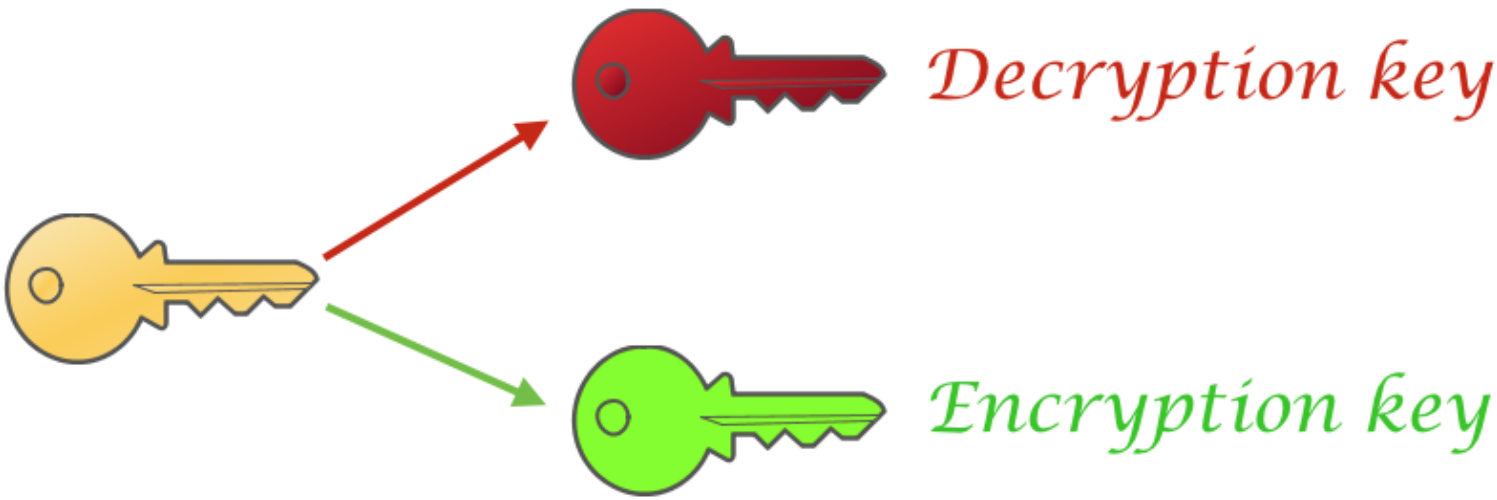
- Uses secret key.
- Unlocks Bob's message.
- Could unlock many messages.
- Secured with same lock.



RSA Encryption

Public Key Cryptography (PK)

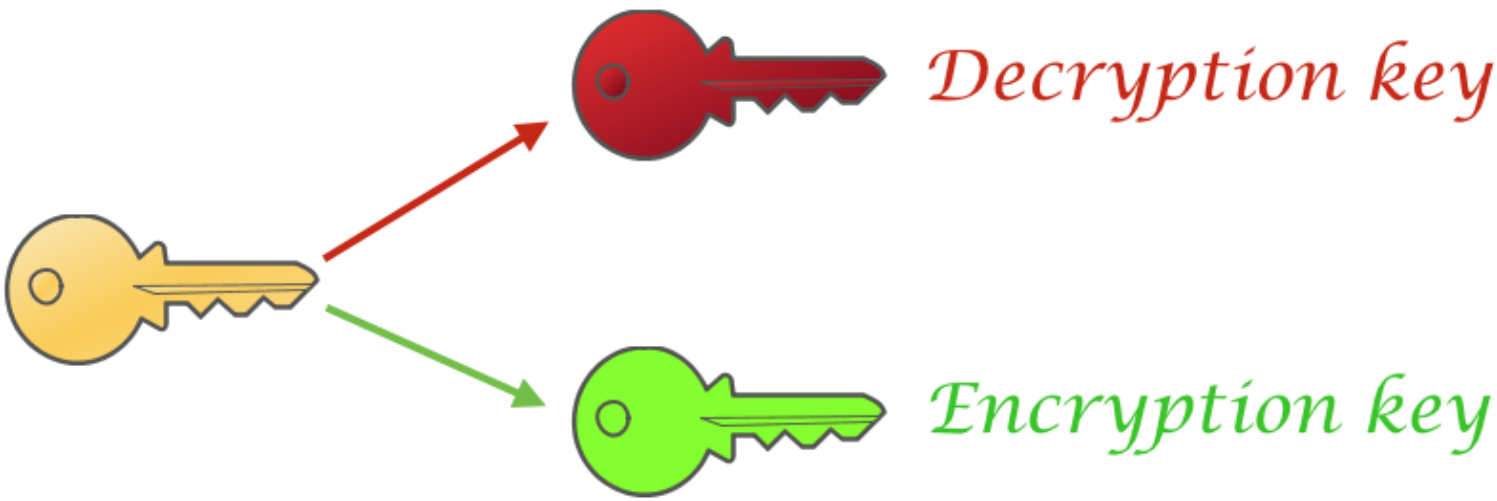
- PK crypto envisaged by James Ellis & mathematically proven by Clifford Cocks in GCHQ (1973).
- Ron **R**ivest, Adi **S**hamir & Leonard **A**dleman discovered independently (1977)



RSA Encryption

Public Key Cryptography (PK)

- Key generator produces two components.
- The private (secret) key (SK) used to decrypt.
- The public key (PK) used to encrypt.
- Keys have inverse functionality.
  - Encrypt with PK => decrypt with SK.
  - Sign (encrypt) with SK => verify (decrypt) with PK.



Secure Shell (SSH)

Underlying cryptographic technologies

Secure Shell (SSH)

Secure Shell (SSH)

Underlying cryptographic technologies

- Symmetric Encryption
- Public Key (Asymmetric) Encryption
- Hashing

Secure Shell (SSH)

Underlying cryptographic technologies

Goal is to achieve:

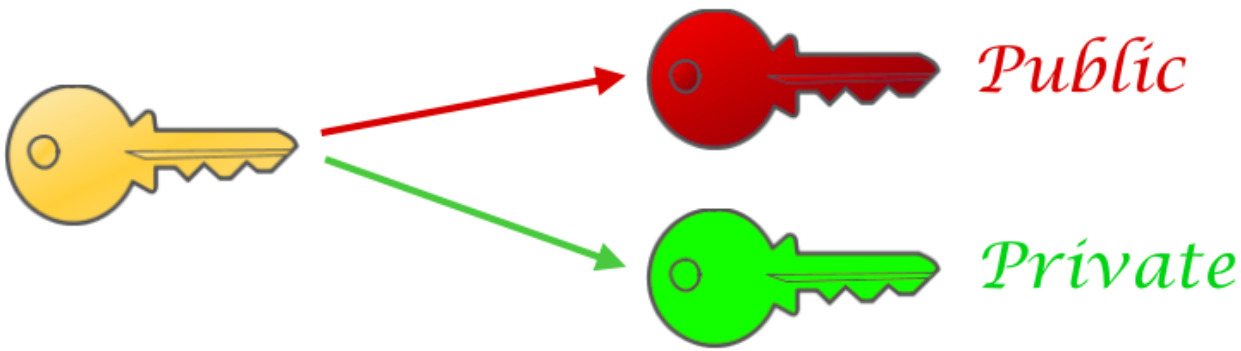
- Authentication
- Message encryption
- Message integrity

Secure Shell (SSH)

Underlying cryptographic technologies

Asymmetric Encryption

- Client generates public-private key pair.
- Public key sent to server.
- Used in symmetric key set up.
- Used for authentication.

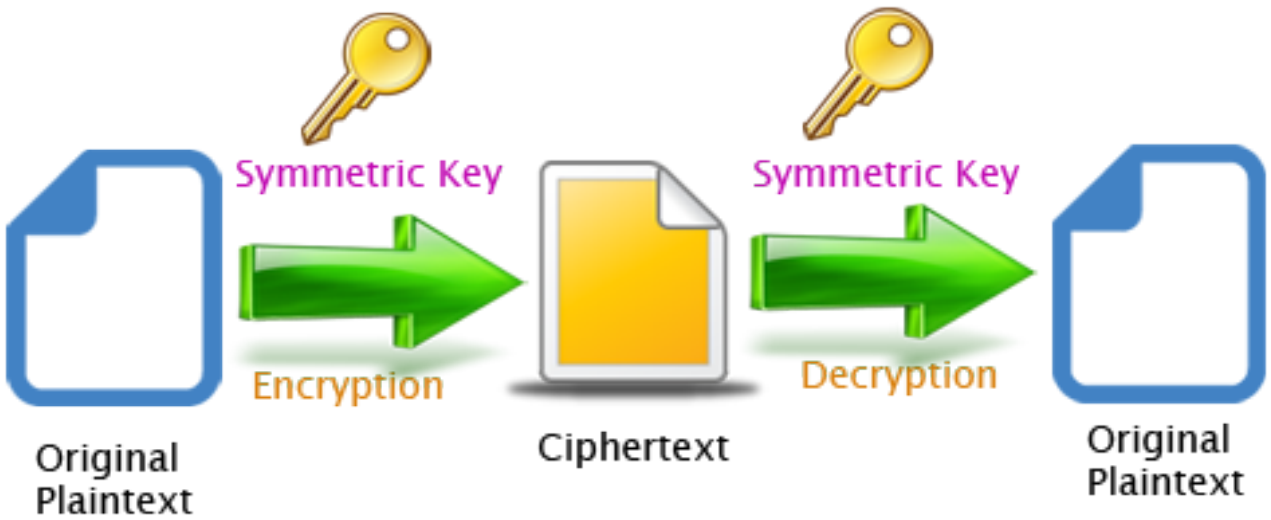


Secure Shell (SSH)

Underlying cryptographic technologies

Symmetric Encryption

- Key exchange algorithm establishes shared secret key.
- This key used to encrypt data.

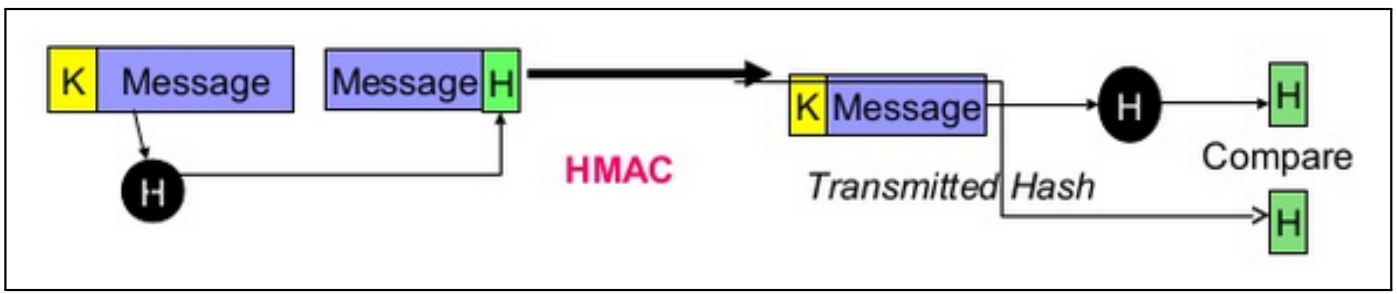


Secure Shell (SSH)

Underlying cryptographic technologies

Hashing

- Hash-based message authentication code (HMAC).
- Used to ensure message integrity (not tampered).
- MAC signing algorithm generates tag using key and message.
- MAC verification algorithm uses key, message and tag.



References

Encryption & Digital Signing

1. Official documentation: Sign Your App

`http://bit.ly/2eIDwQE` [Accessed 2016-10-19]

2. Khan Academy: Journey into Cryptography

`http://bit.ly/2eIyBPO`

[Accessed 2016-10-27]

3. Mathematical Cryptosystems (1 of 2): Symmetric Cryptography

`http://bit.ly/2ey52Ti`

[Accessed 2016-10-27]

References

Encryption & Digital Signing

4. Mathematical Cryptosystems (2 of 2): Symmetric Cryptography

`http://bit.ly/2eOTpFV`

[Accessed 2016-10-27]

5. KhanAcademy: Digital Signatures High-level Description

`http://bit.ly/2eUCT5I`

[Accessed 2016-10-27]

6.Public Key Encrpyion & Digital Signature: How do they work?

`https://goo.gl/lHHsRo`

[Accessed 2016-10-28]

References

Encryption & Digital Signing

6. How PGP Works

https://goo.gl/2UKnR5

[Accessed 2016-10-28]

7. KhanAcademy: Modern Cryptography

https://goo.gl/xXg4w9

[Accessed 2016-11-06]

8. Android Development: Keytool, creating a keystore?

https://goo.gl/ZzDto4

[Accessed 2016-11-06]

References

Encryption & Digital Signing

9. Oracle SE Documentation: jarsigner

https://goo.gl/YMSL4f

[Accessed 2016-11-06]

10. Android APK Signature Scheme V2

https://goo.gl/R8d4Bz

[Accessed 2016-11-06]

11. Android Application Signing

https://goo.gl/A95Tv9

[Accessed 2016-11-06]

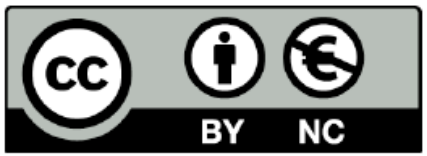
References

Encryption & Digital Signing

12. Understanding SSH

`https://goo.gl/CqwN4s`

[Accessed 2016-11-16]



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