Mobile Application Development
Sign Your App

Waterford Institute of Technology

November 16, 2016

John Fitzgerald

Sign your app

Learning objectives

An overview of:

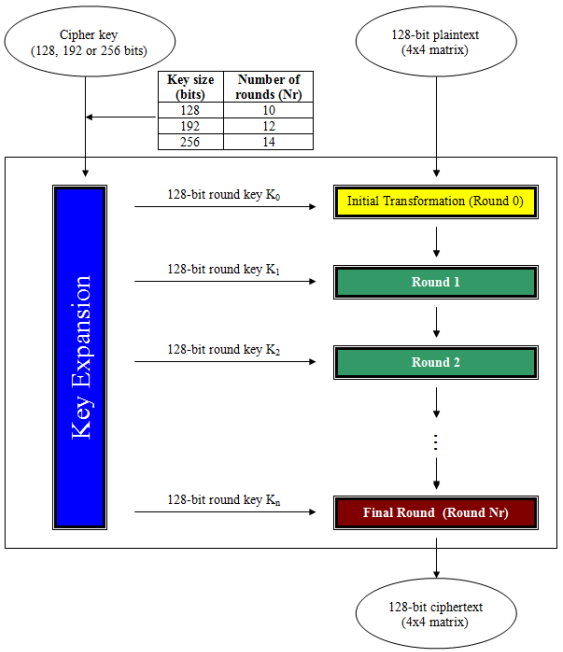
- Symmetric key encryption
- Public key encryption
- Cryptographic hash function
- Exchange secret key in public channel
- Review programming module crypto
- Certificates
- Signing app
- Key storage and security

Sign your app

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

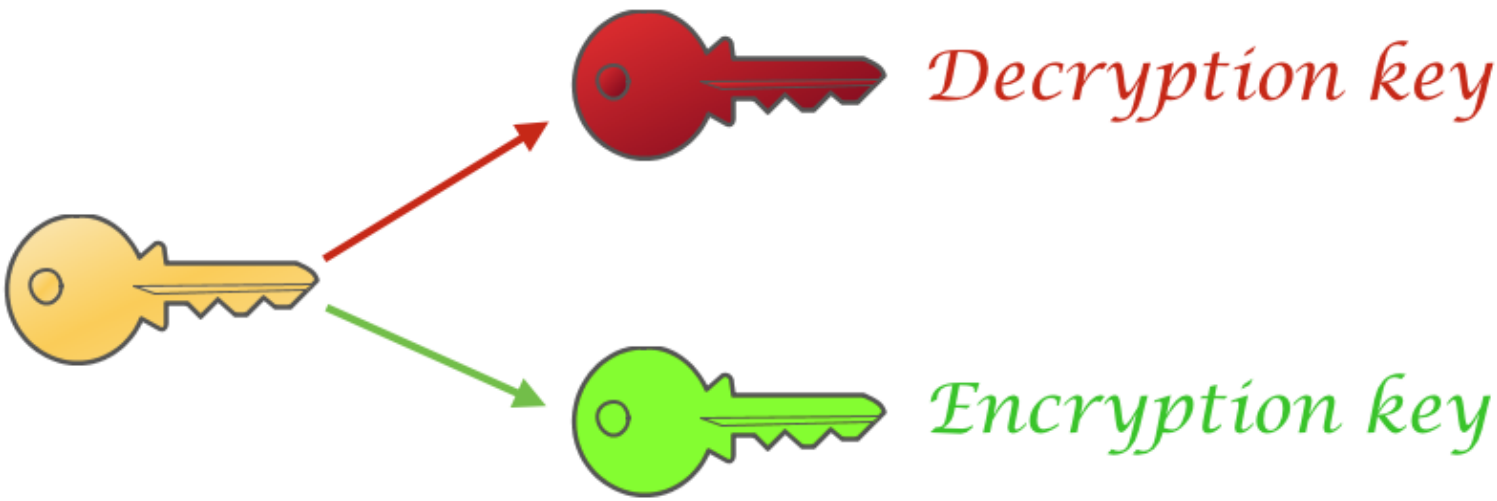
Android Studio

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.



Sign your app

Certificates and Keystores

Public-key certificate

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

Sign your app

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.

Sign your app

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.

Sign your app

Digital Signature Scheme

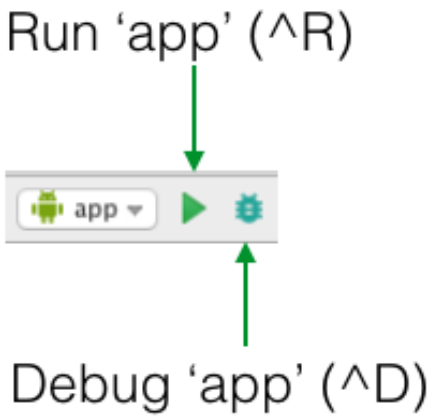
Android implementation (v2):

- 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.

Sign your app

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.



Sign your app

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.

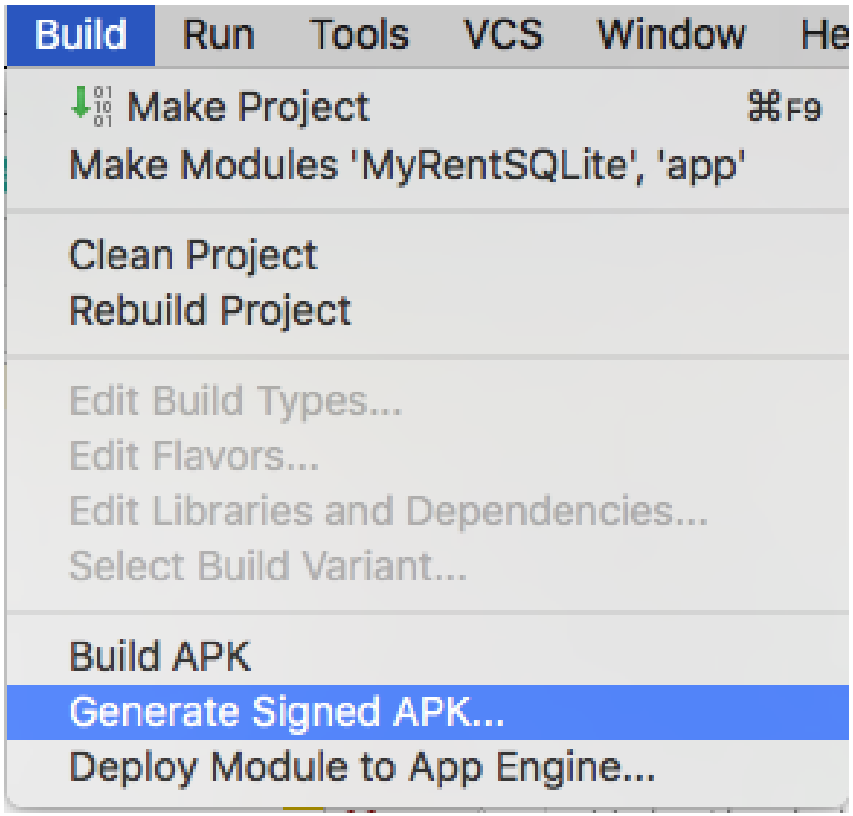
Sign your app

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.

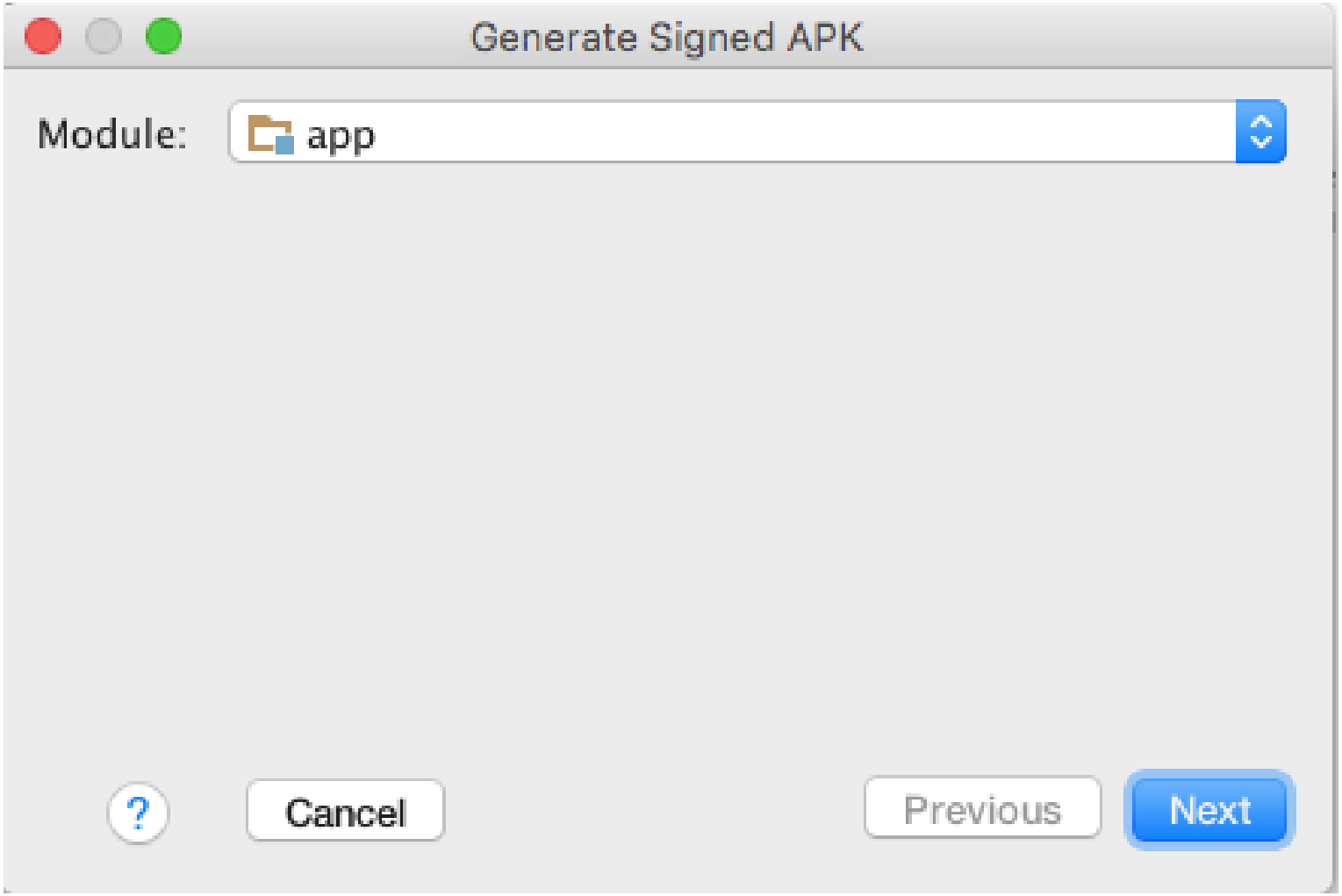
Sign your app

Manually using Android Studio



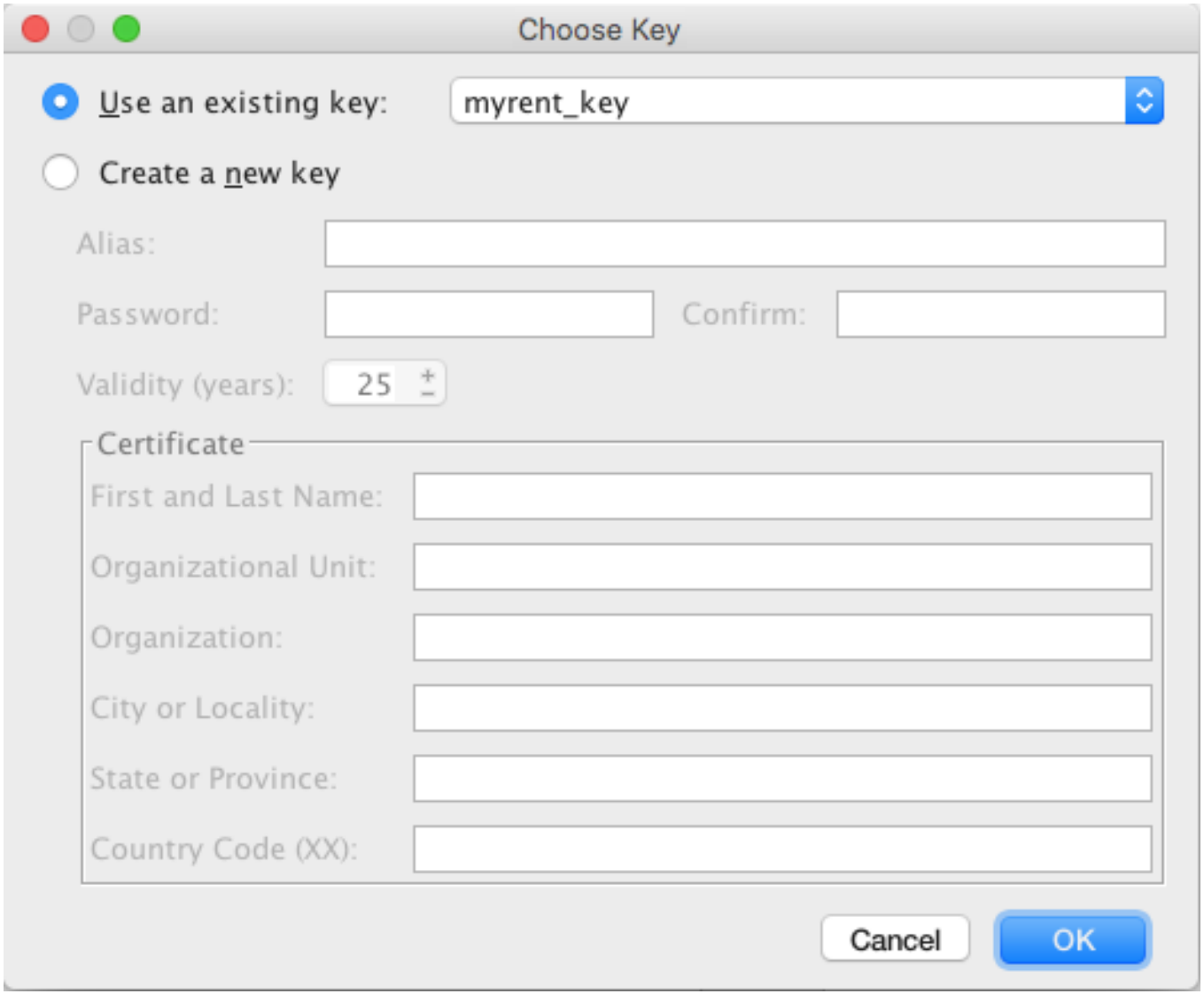
Sign your app

Manually using Android Studio



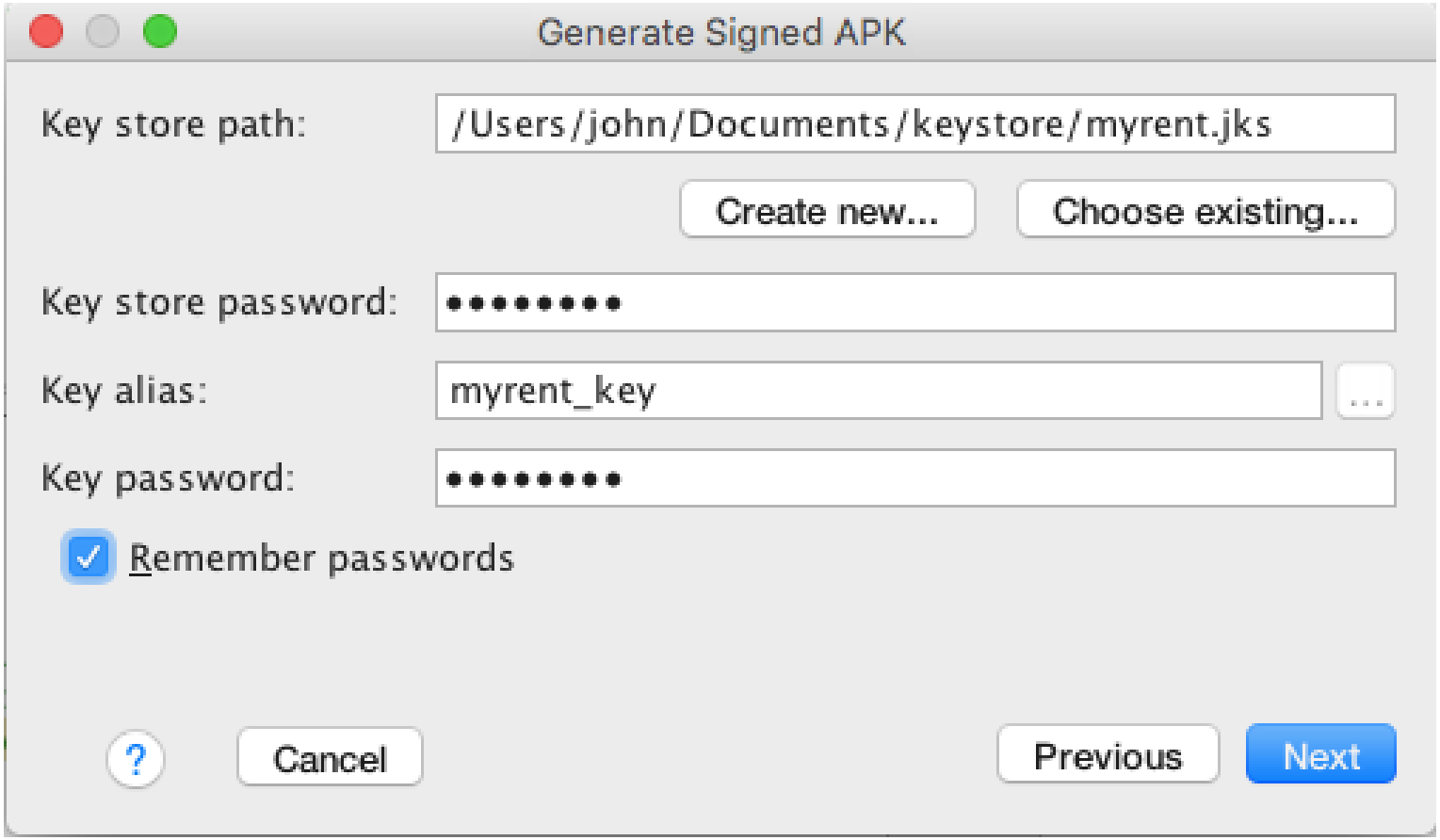
Sign your app

Manually using Android Studio



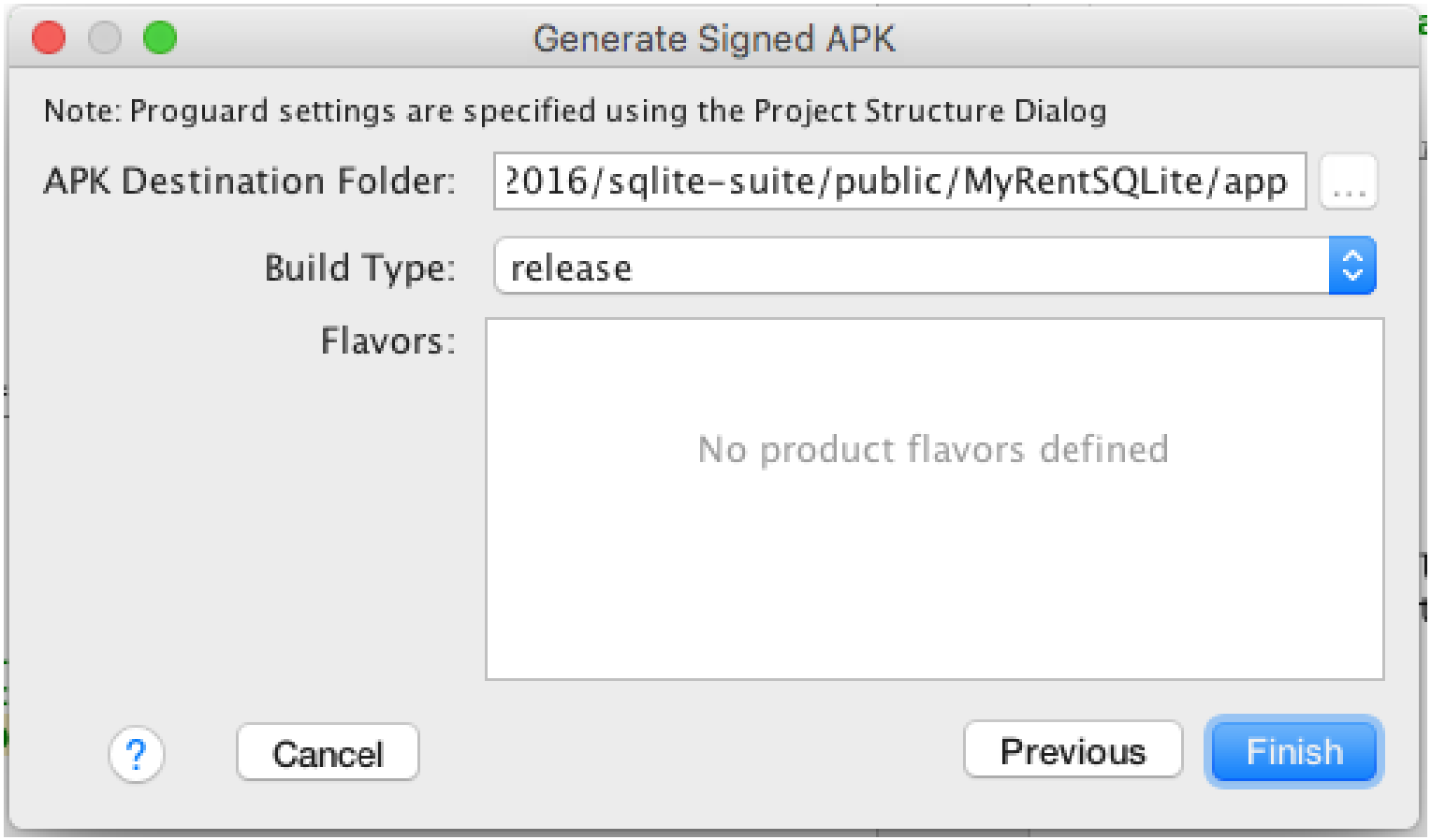
Sign your app

Manually using Android Studio



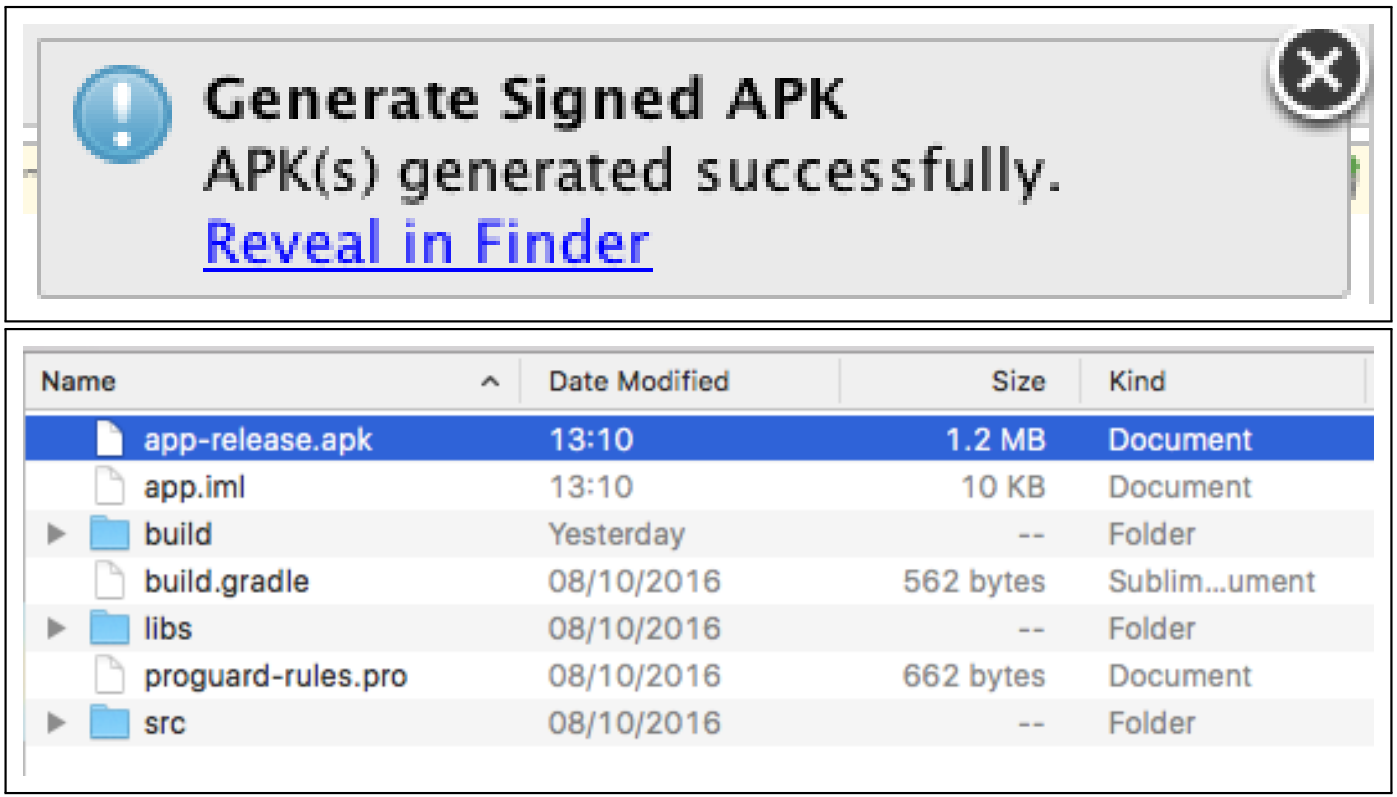
Sign your app

Manually using Android Studio



Sign your app

Manually using Android Studio



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/

Sign your app

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

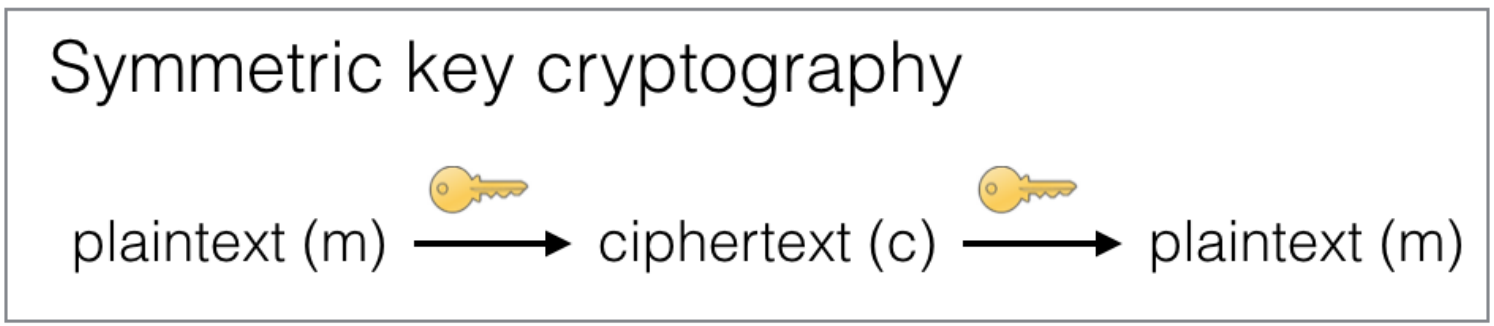
A brief exploration

Basics of Cryptographic Technology

Supporting cryptograpic technology

Three types cryptography

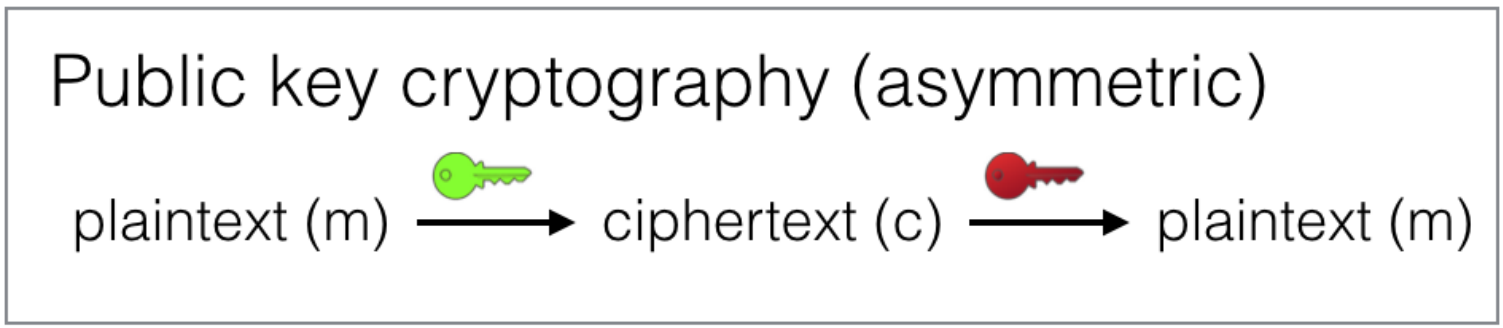
Single key used for both encryption and decryption.



Supporting cryptograpic technology

Three types cryptography

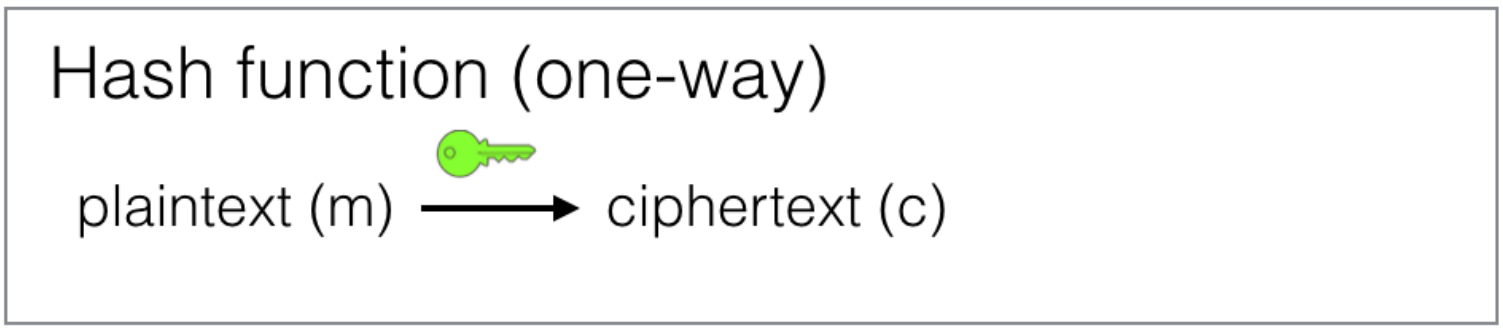
Key pair: secret and public.



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.

Sign your app

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

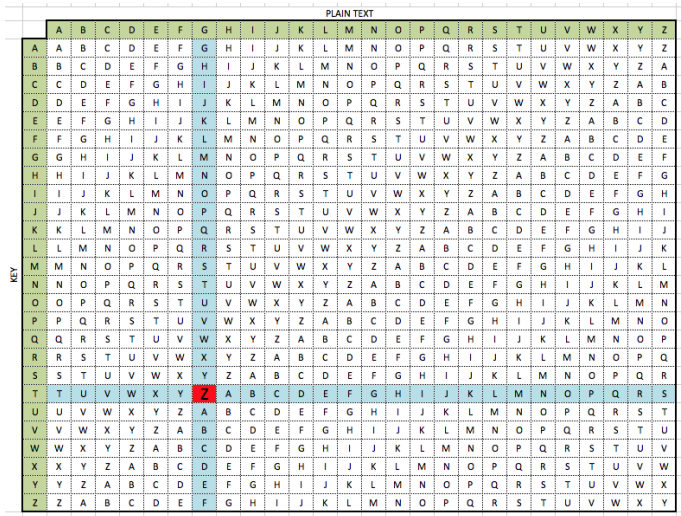
Caesar cipher

- 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

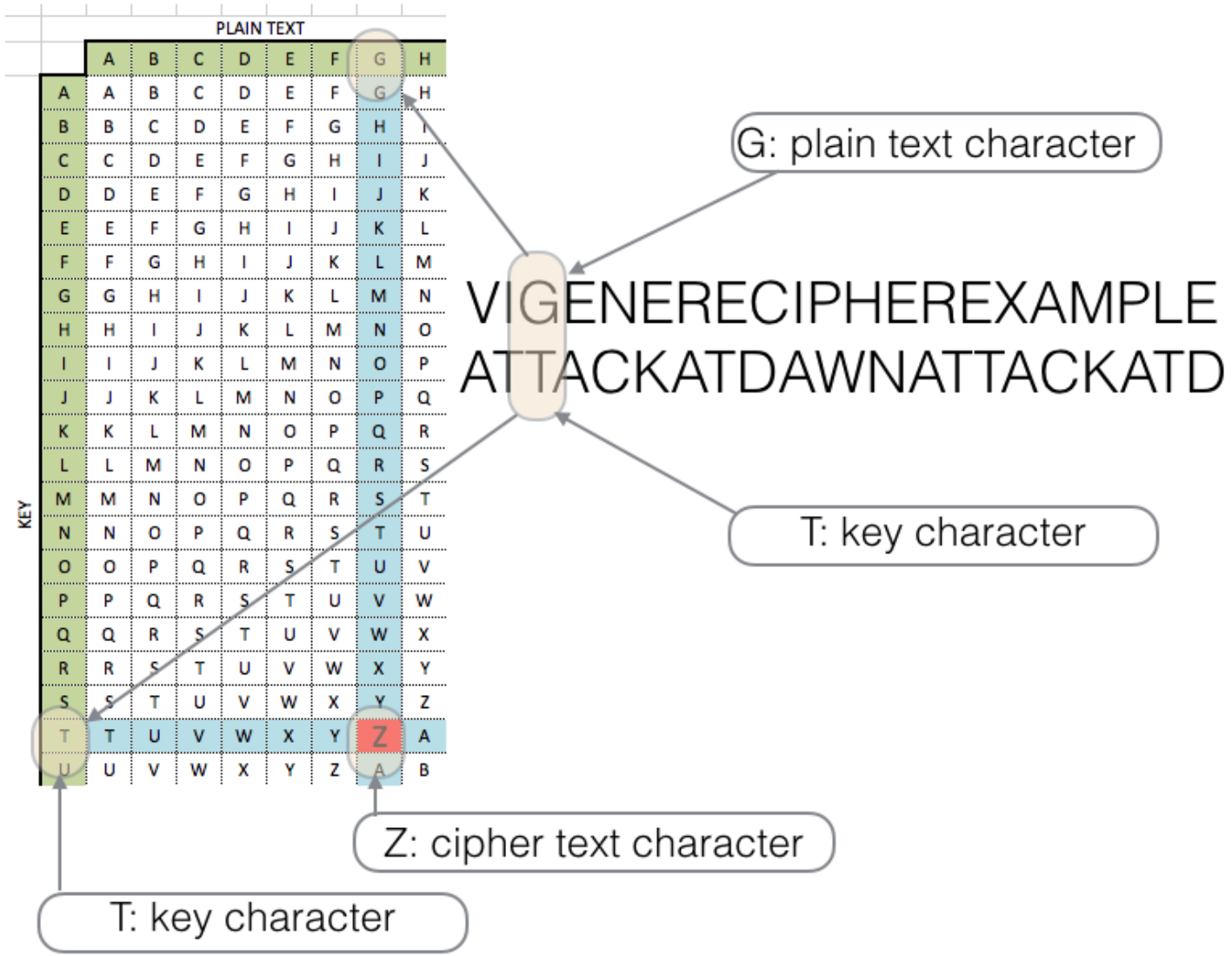
Key length matches plain text

- 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:

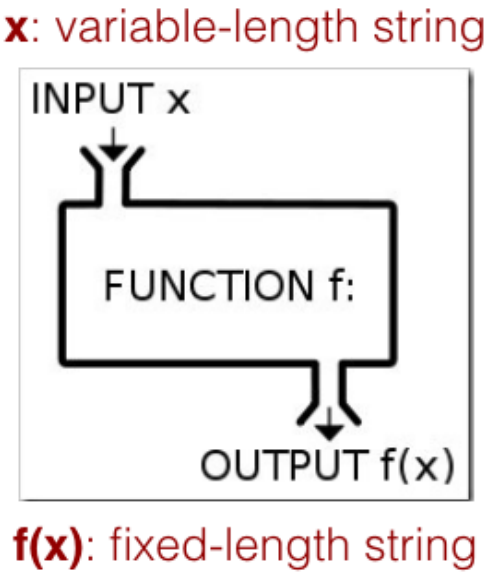
- $c = m \oplus k$
- $m = c \oplus k$

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?

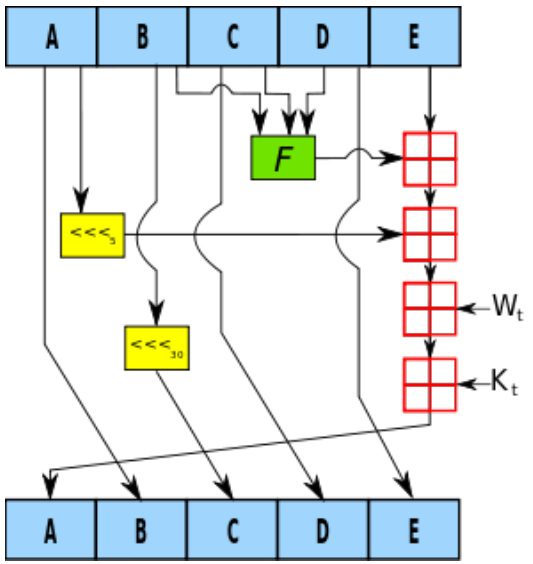
- What is a hash?
  - A fixed-length string.
  - The output from a function.
  - Known as hash function.
  - Whose input is a string of any length.



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

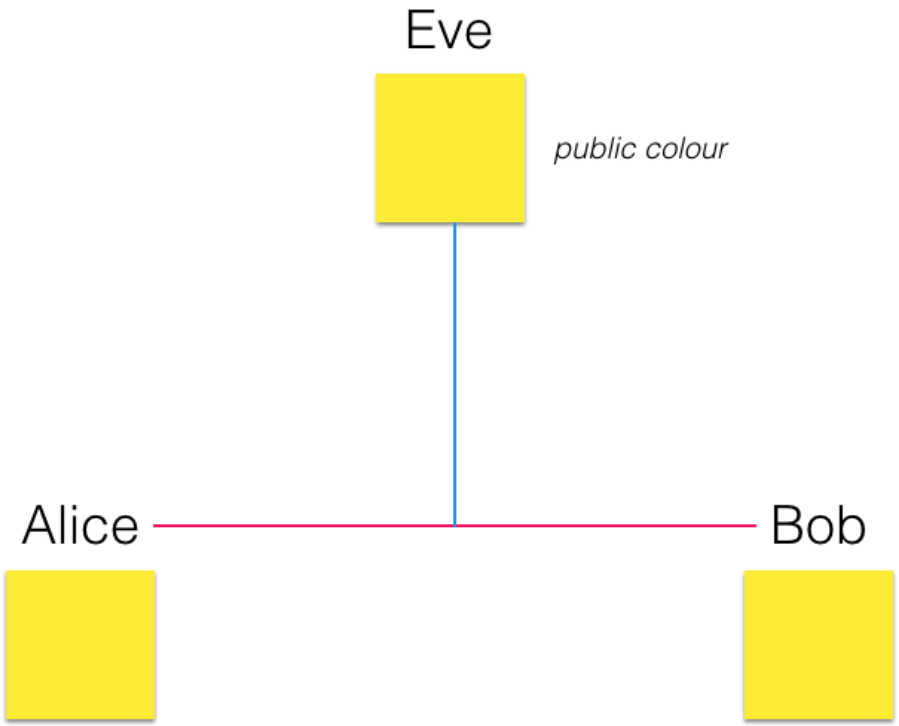
Creating shared secret key

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).

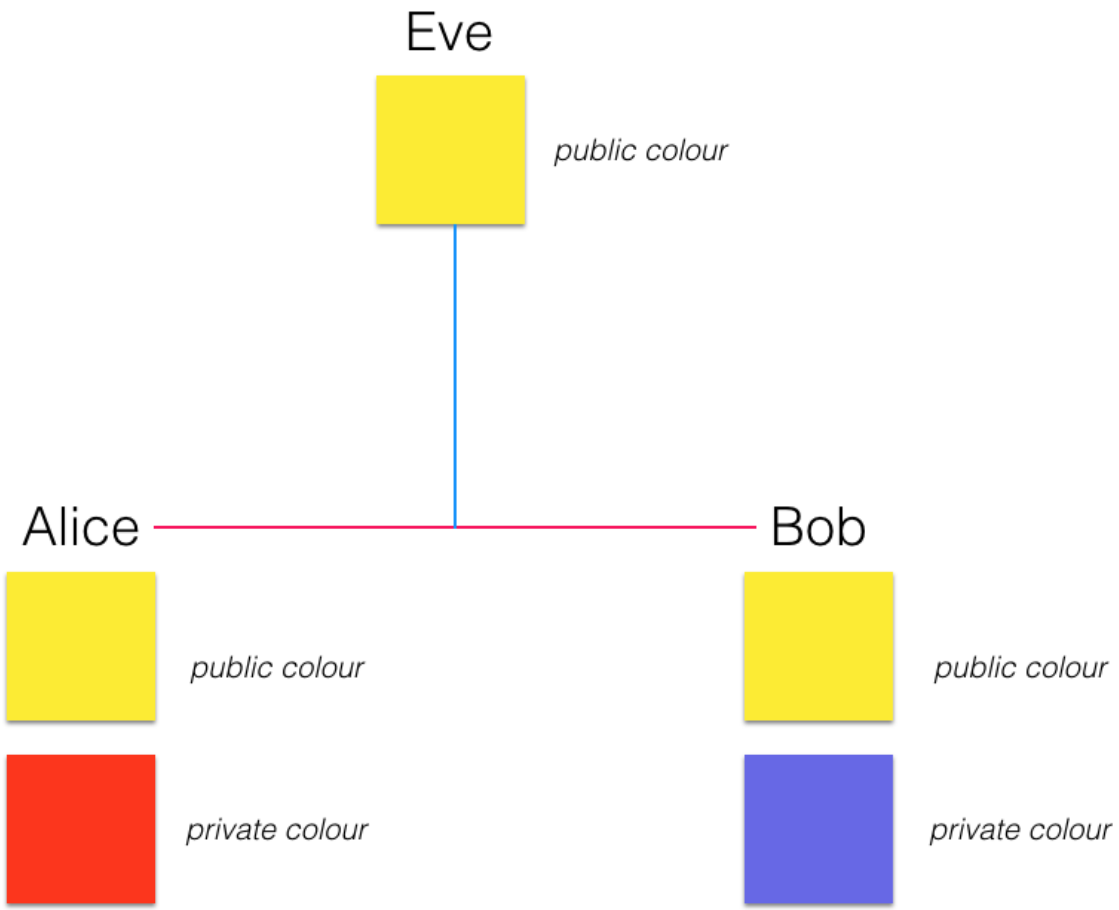
Key exchange explained using colours

A random colour published



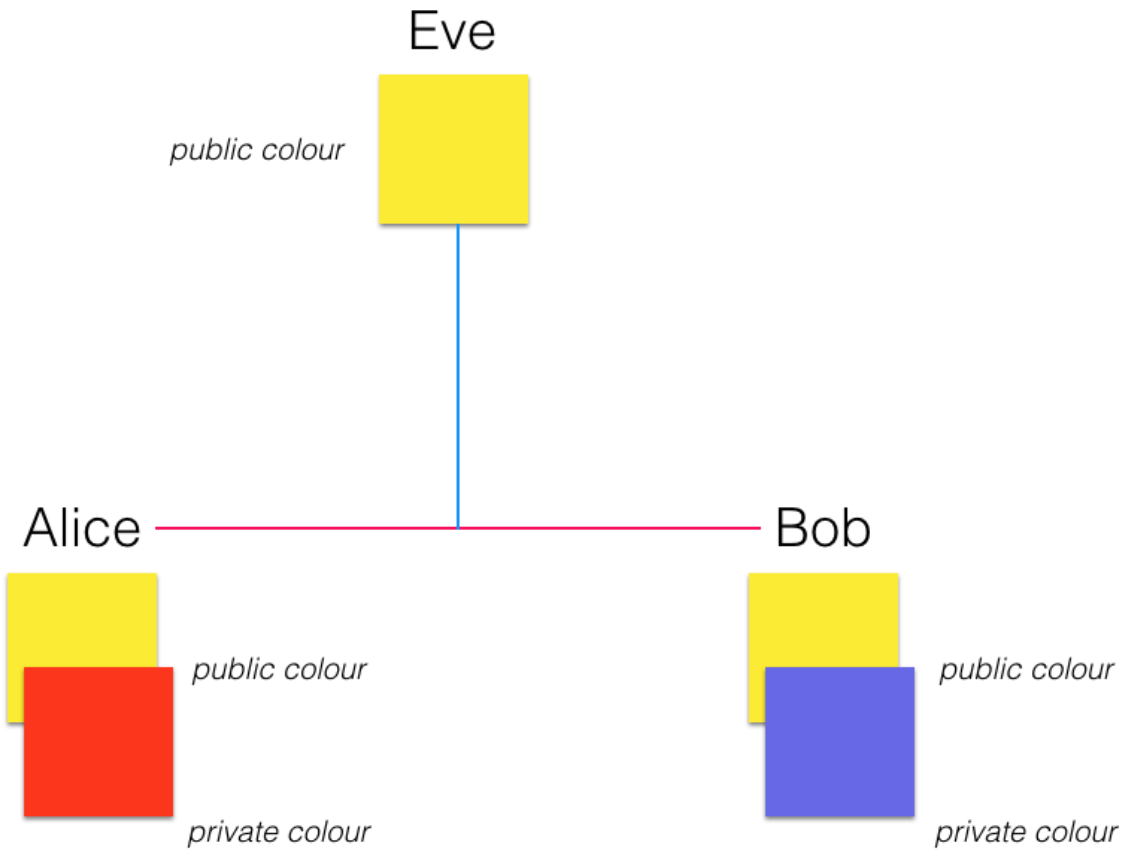
key exchange

Alice & Bob each randomly select a secret colour



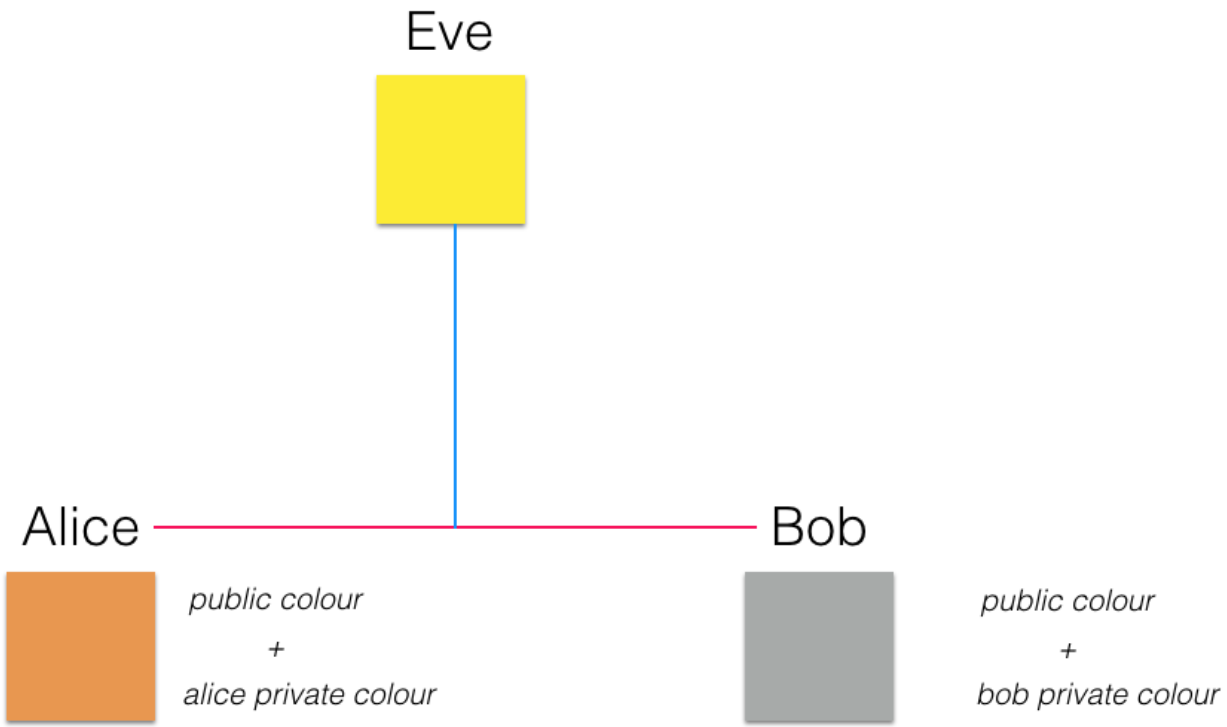
Key exchange

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



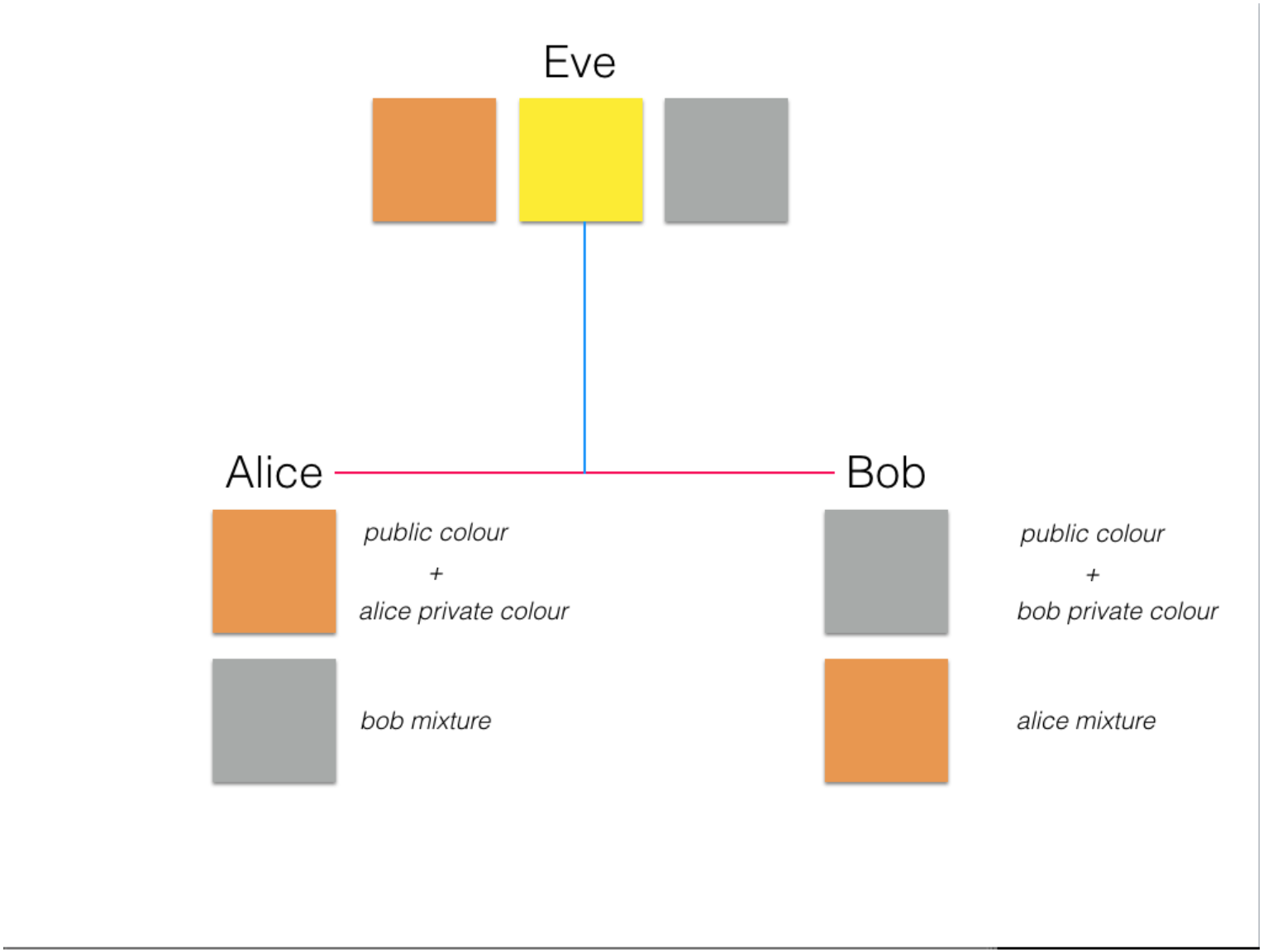
Key exchange

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



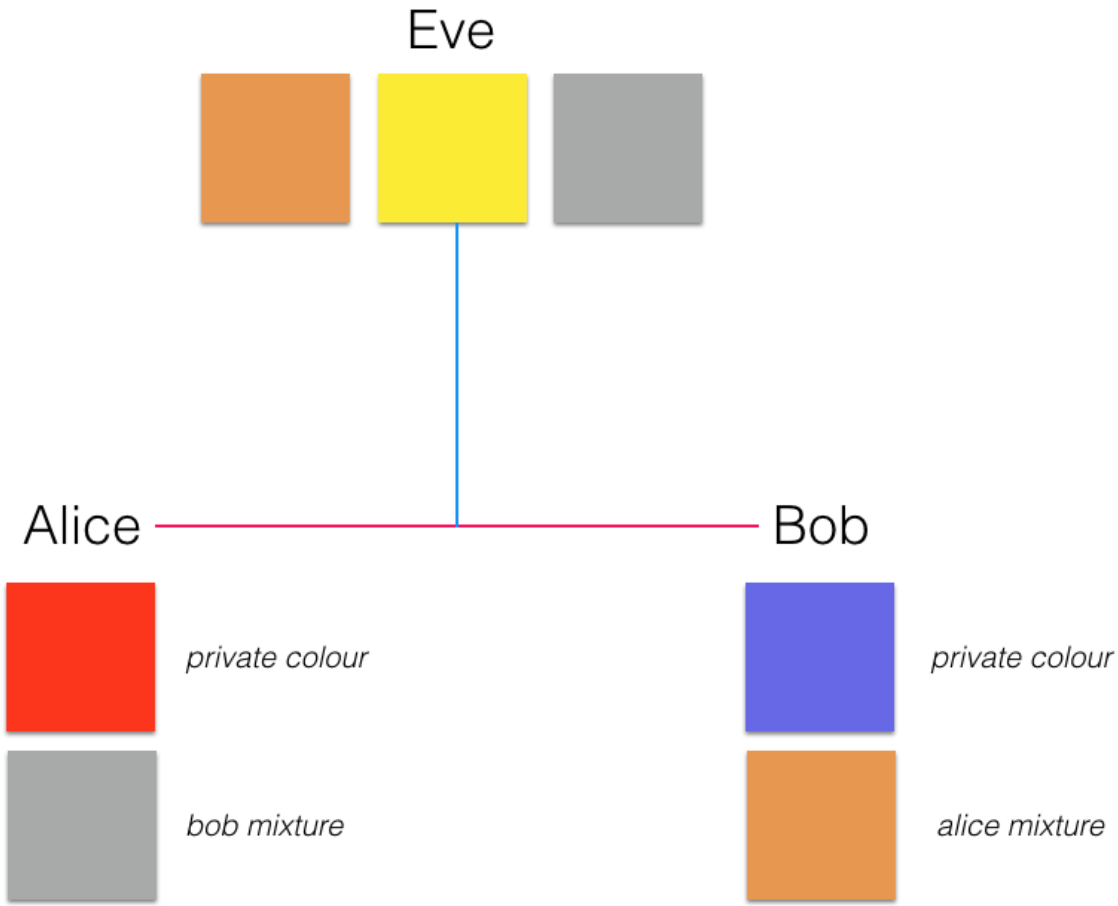
Key exchange

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



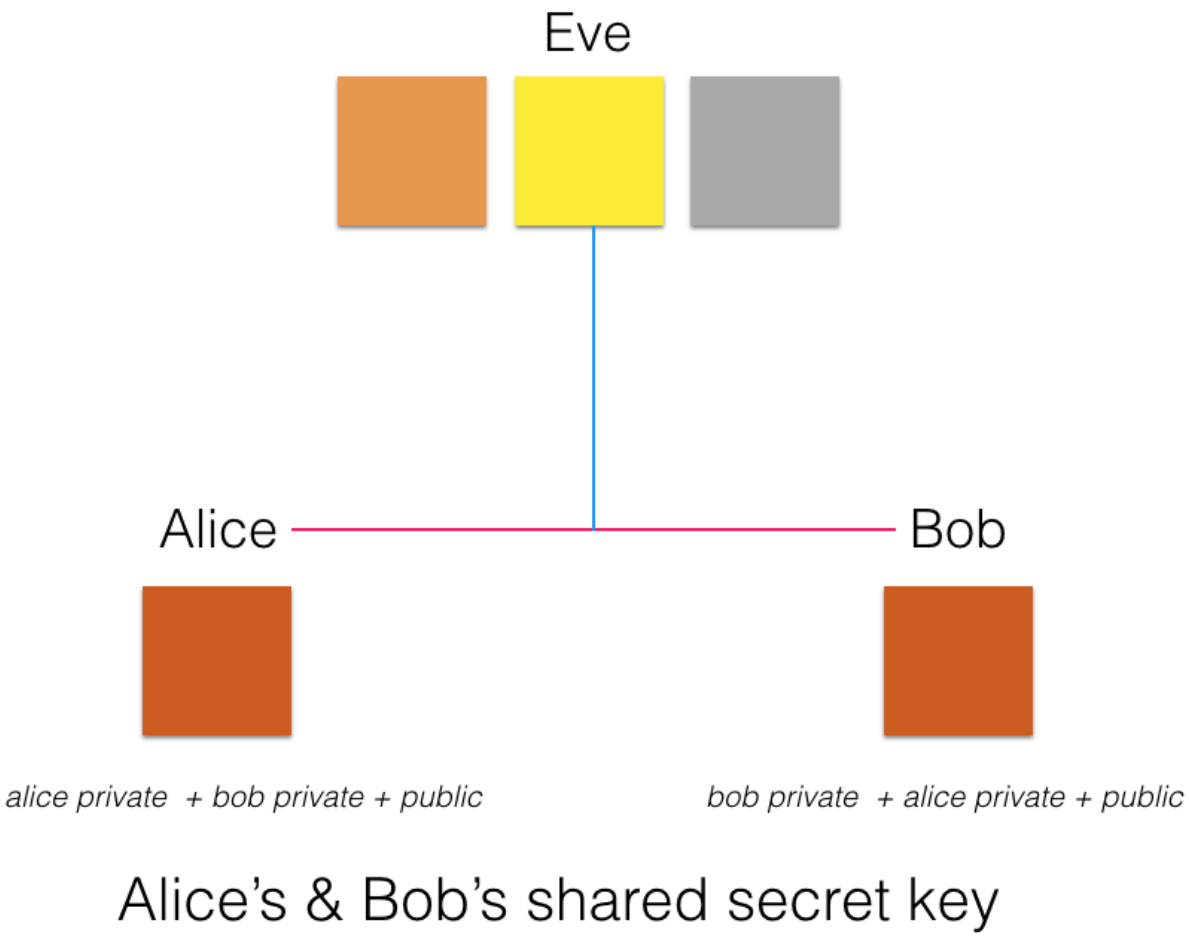
Key exchange

Alice & Bob each add private colour to mixed colors



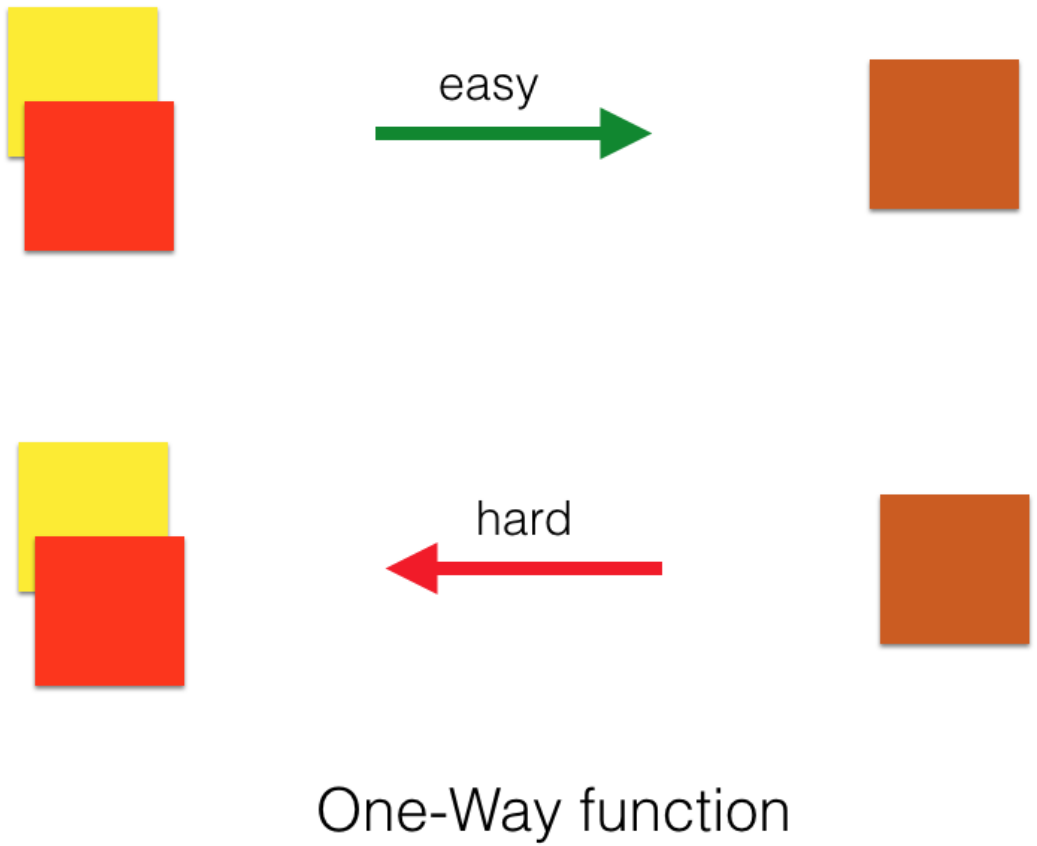
Key exchange

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



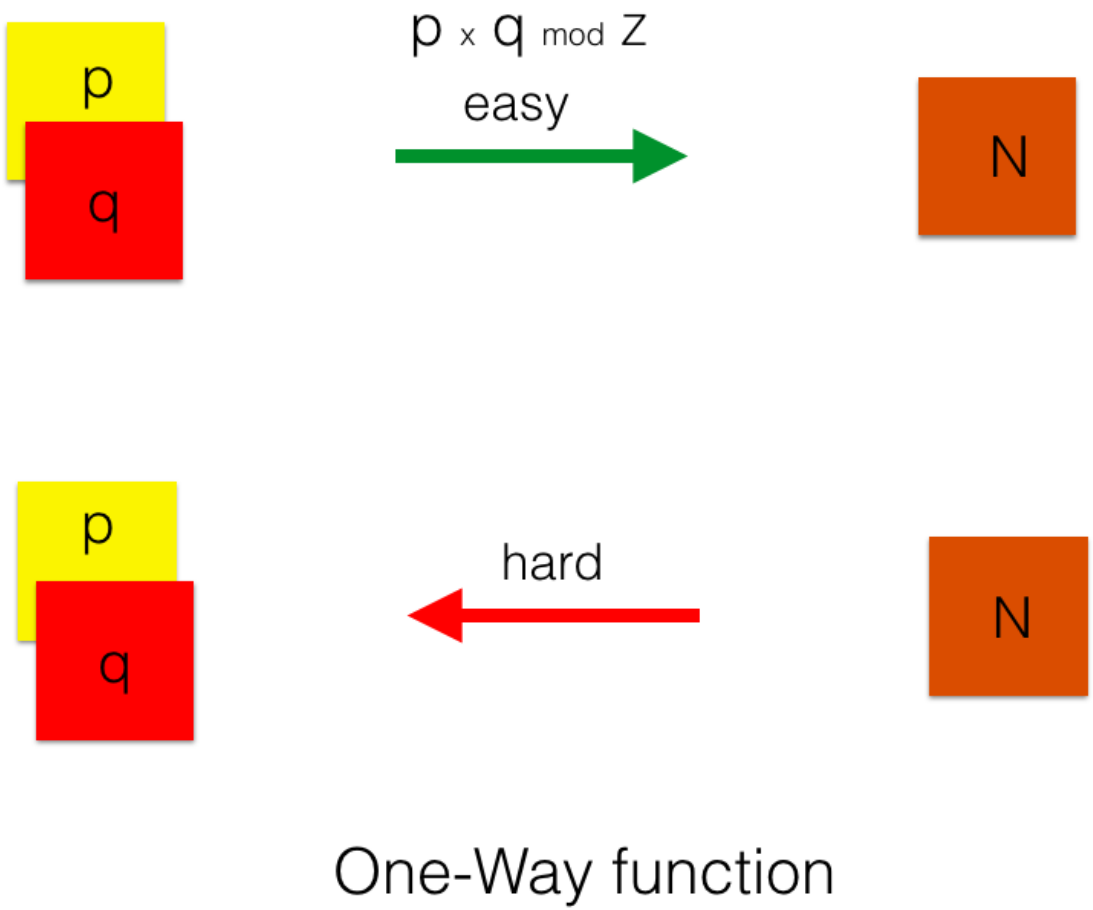
Key Exchange

Uses One-Way Function



Key Exchange

Uses One-Way Function



One-Way function

Public Key Cryptography

Public-private key pair

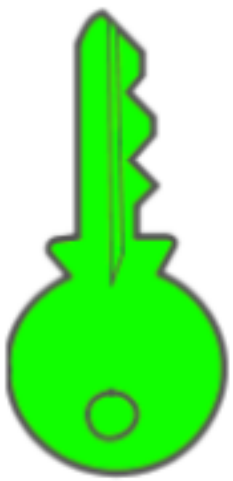
$\mathcal{RSA}$

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:

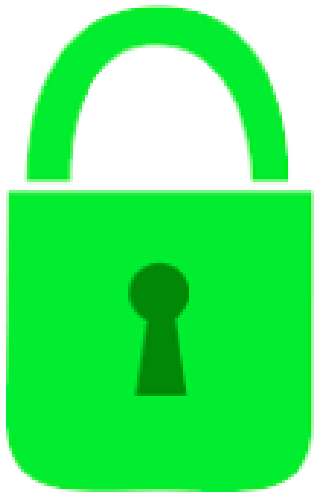
- Sends open lock to Bob.
- Could send same lock multiple people.

RSA Encryption

public-private key pair

Bob:

- Locks message.
- Returns to Alice.

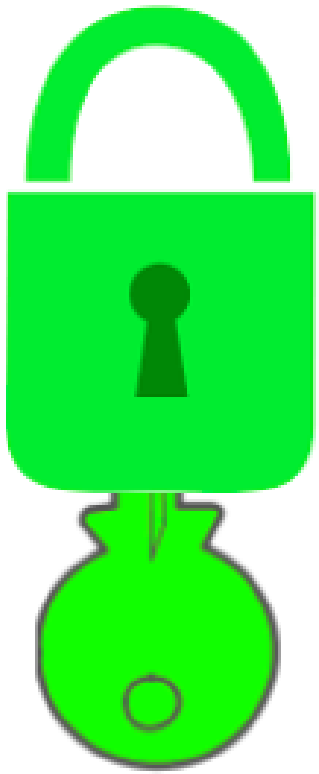


RSA Encryption

public-private key pair

Alice:

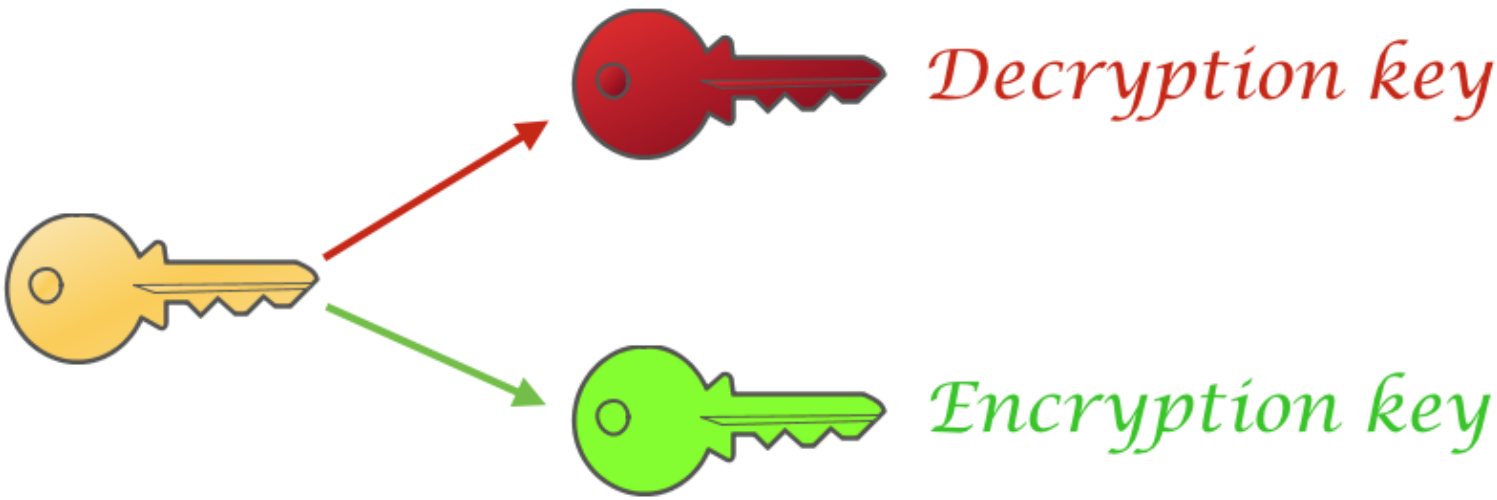
- Uses secret key.
- Unlocks Bob's message.
- Could unlock many messages.
- Secured with same lock.



RSA Encryption

Public Key Cryptography (PK)

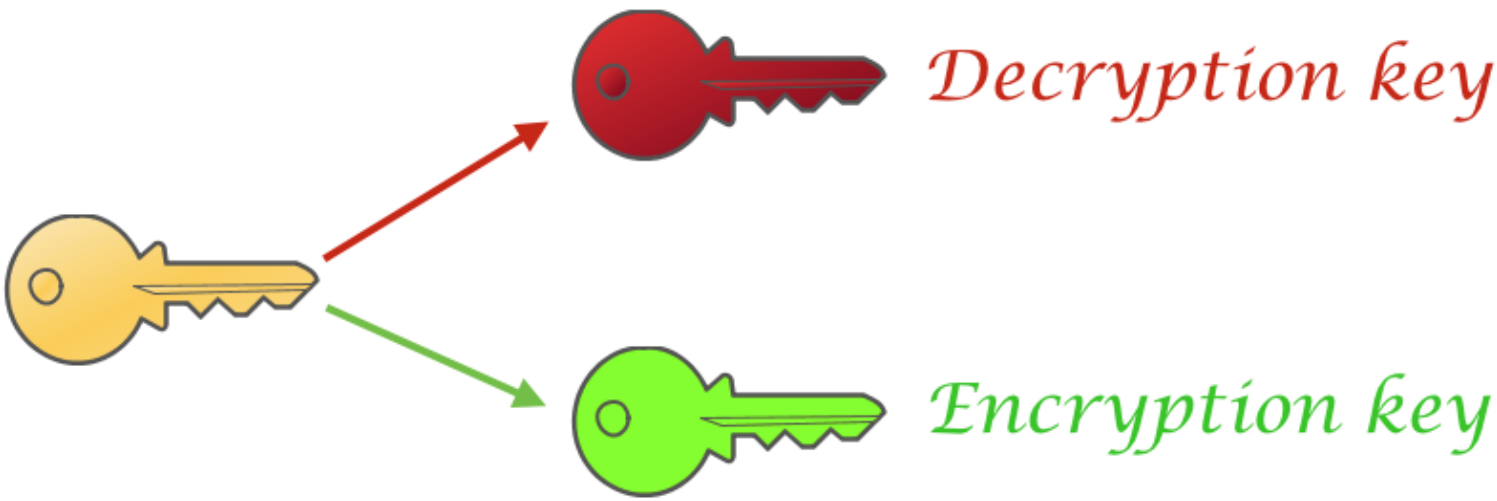
- PK crypto envisaged by James Ellis & mathematically proven by Clifford Cocks in GCHQ (1973).
- Ron **R**ivest, Adi **S**hamir & Leonard **A**dleman discovered independently (1977)



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.



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

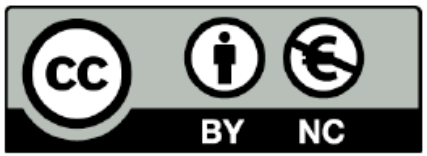
`https://goo.gl/R8d4Bz`

[Accessed 2016-11-06]

11. Android Application Signing

`https://goo.gl/A95Tv9`

[Accessed 2016-11-06]



Waterford Institute *of* Technology
INSTITIÚID TEICNEOLAÍOCHTA PHORT LÁIRGE

eLearning support unit