Aaron Wilson

Teaching experience

- Mentoring and development colleagues
- Problem classes and tutorials during my Ph.D

Topics / Modules

- Information / Computer Security
- Cryptography
- Programing and software development

A distraction

You are in Wales.

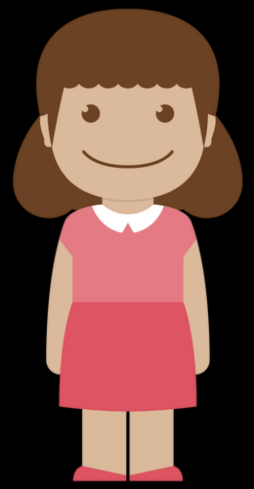
A bookworm eats from the first page of volume 1 to the last page of volume 3 in a 3-volume encyclopedia, which are stacked on the library shelves. Each volume is 3 centimeters wide.

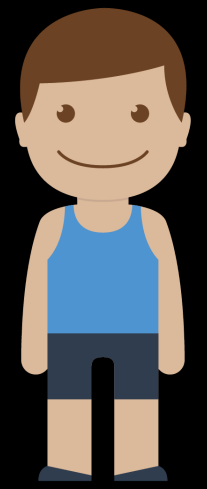
How many centimeters has the bookworm eaten through ? More importantly, *why* is this the answer ?

Cryptographic Key Exchange

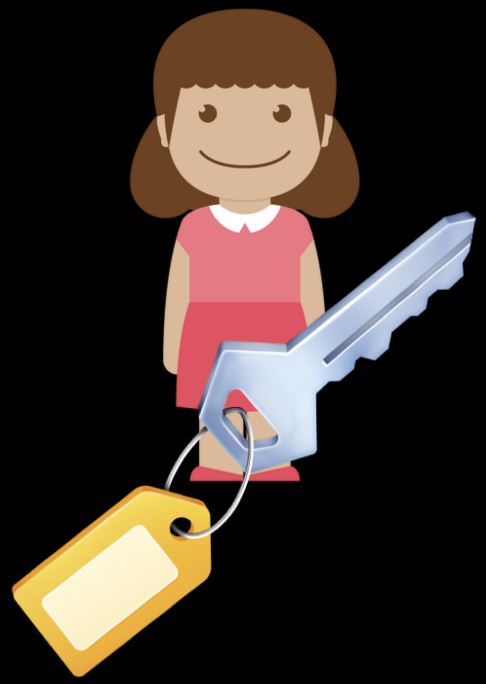
- Understand why we would want a key exchange mechanism
- Understand how the Diffie Hellman mechanism works
- Understand why the Diffie Hellman mechanism is secure

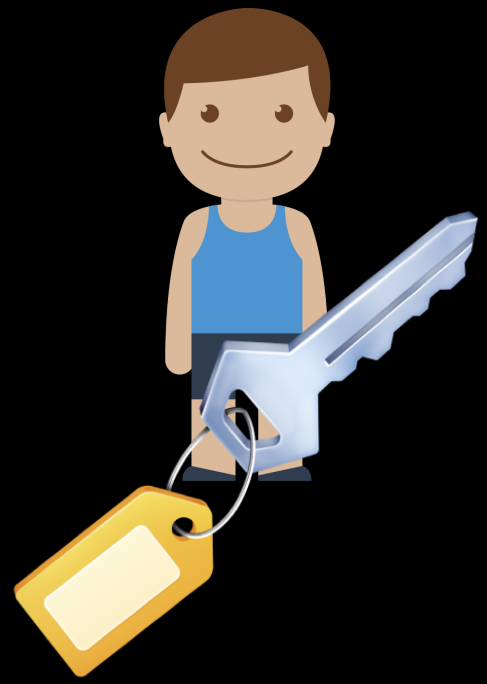
Symmetric Cryptography



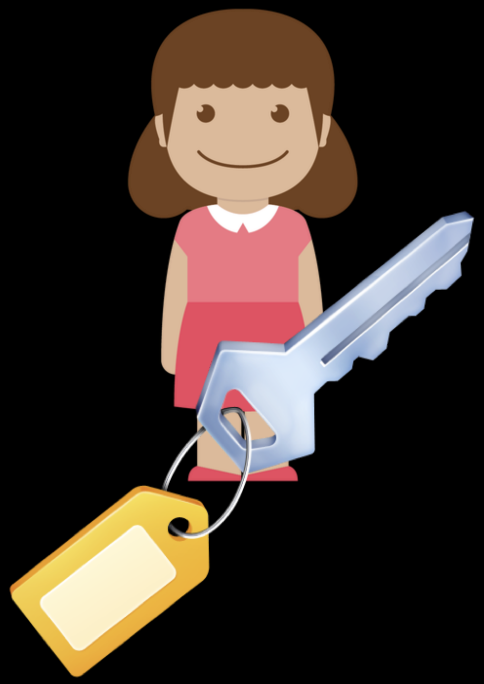


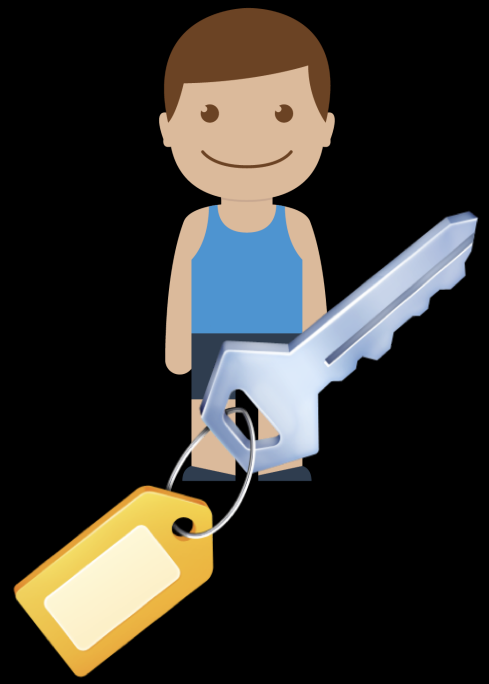
Symmetric Cryptography



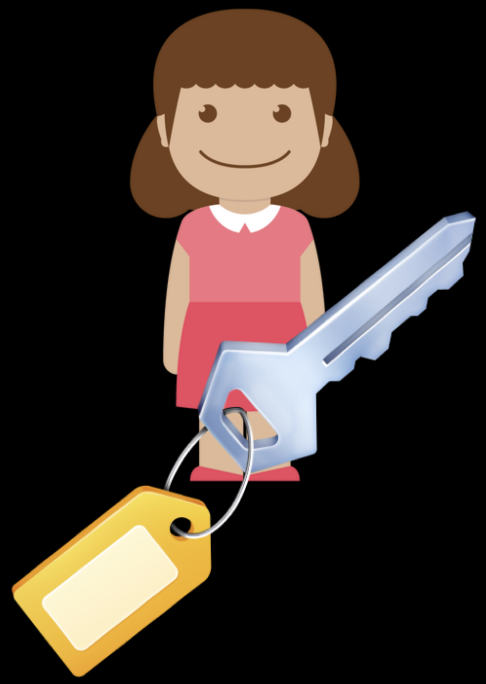


Symmetric Cryptography

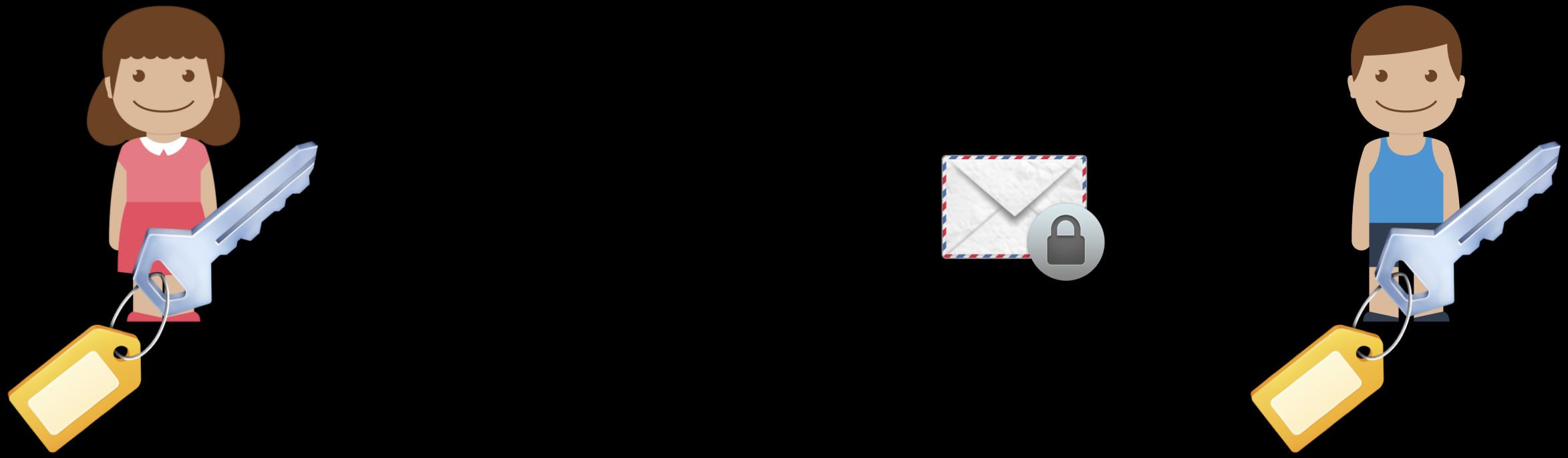




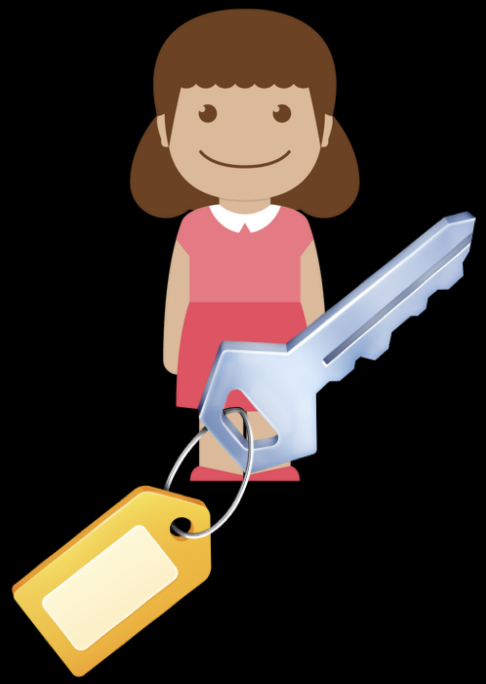
Symmetric Cryptography

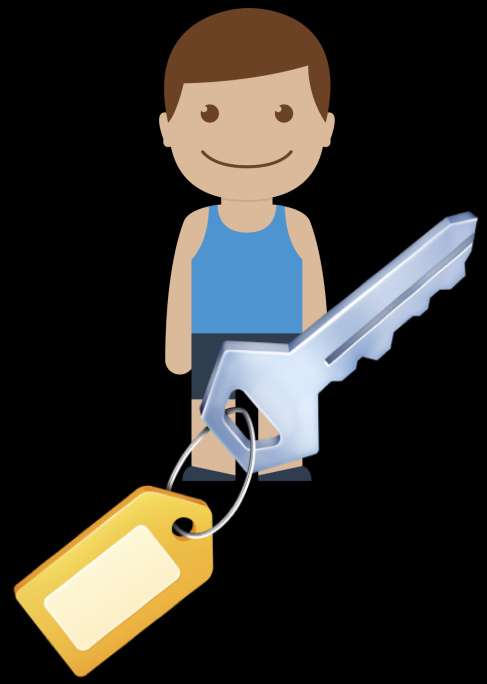


Symmetric Cryptography

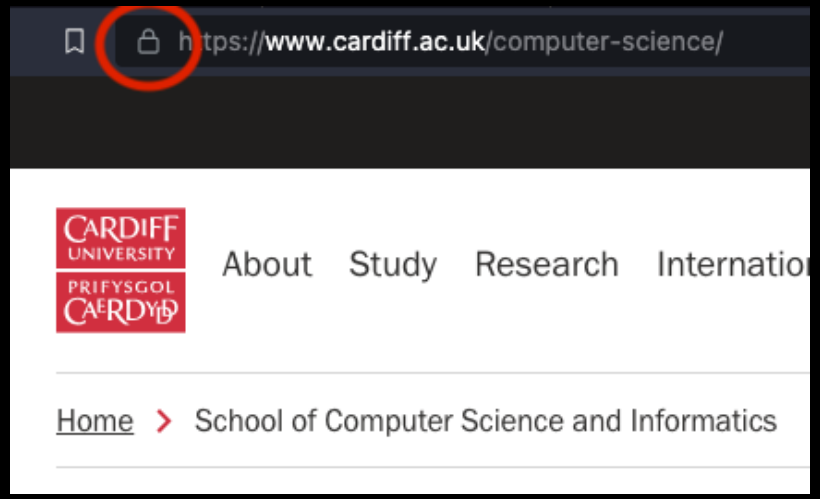


Symmetric Cryptography





Transport Layer Security



What properties should a mechanism have ?

- Not rely on previously shared *secret* information
- Agreement
- Possibly also: authentication
- Computationally efficient

Diffie Hellman Key Exchange

- Based on a concept of Ralph Merkle
- First published in 1976 by Whitfield Diffie and Martin Hellman
- One of the first public key protocols
- Non-authenticated key agreement protocol

In action (simple)

How does it work

- Factorisation is computationally hard
  - $23 * 97 = ?$
  - Factor 4321
  - Quantum computers
- Or equivalently the Discrete Logathrim problem is hard

Algorthim (Simplest form, slide 1 of 2)

- Agree on a public prime p as a modulus, and a primitive root to use as a base g
  - e.g let's pick $p = 23$, and $g = 5$
- The first person picks a secret a and calculates $g^a \mod p$
  - Let's have $a = 4$ so that
    $g^a = 5^4 = 625 = 23 * 27 + 4 = 4 \mod 23$
- The second person picks a secret b and calculates $g^b \mod p$
  - Let's have $b = 3$ so that
    $g^b = 5^3 = 125 = 23 * 5 + 10 = 10 \mod 23$

Algorithm (Simplest form, slide 2 of 2)

- The parties exchange their values
- The first person now calculates the key, $g^{ab} = (g^b)^a \mod p$
  - That is the first party gets 10, so calculates
    $10^4 = 10000 = 23 * 434 + 11 = 18 \mod 23$
- The second person now calculates the key, $g^{ab} = (g^a)^b \mod p$
  - That is the second party receives 4, so calculates
    $4^3 = 64 = 2 + 18 \mod 23 = 18 \mod 24$

Public Information

- The modulus p and primitive root g (in our example 23 and 5)
- The transmitted values between Alice and Bob - g^a and g^b (in our example 4 and 10)
- Thus we can work out g^{a+b}, g^{a-b}
- **BUT NOT** g^{ab}

In action

Security Properties

- Solve the discrete logarithm problem
- person-in-the-middle-attacks
- Logjam
  - first made public 2015-05-20

Exercises / things to discuss

- Go though the example in the text above, and confirm it works
- Come up with other examples, and then try to break them
- person-in-the-middle attack: how does this work ?
- Could this work with more than two people involved ?

Thank you !

Source code and slides are at https://github.com/optimism-marjoram/diffie_hellman

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