CS326 – Systems Security

Lecture 9

Cryptographic Hash Functions

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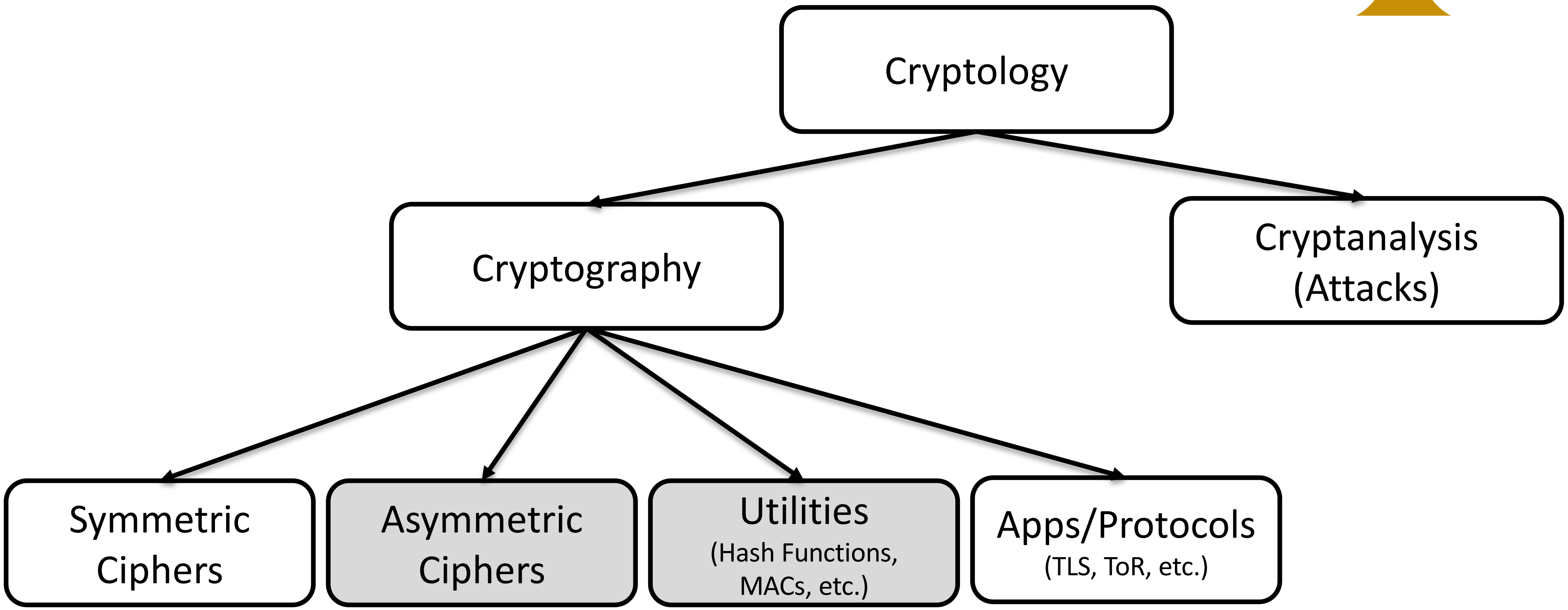
Cryptography Roadmap

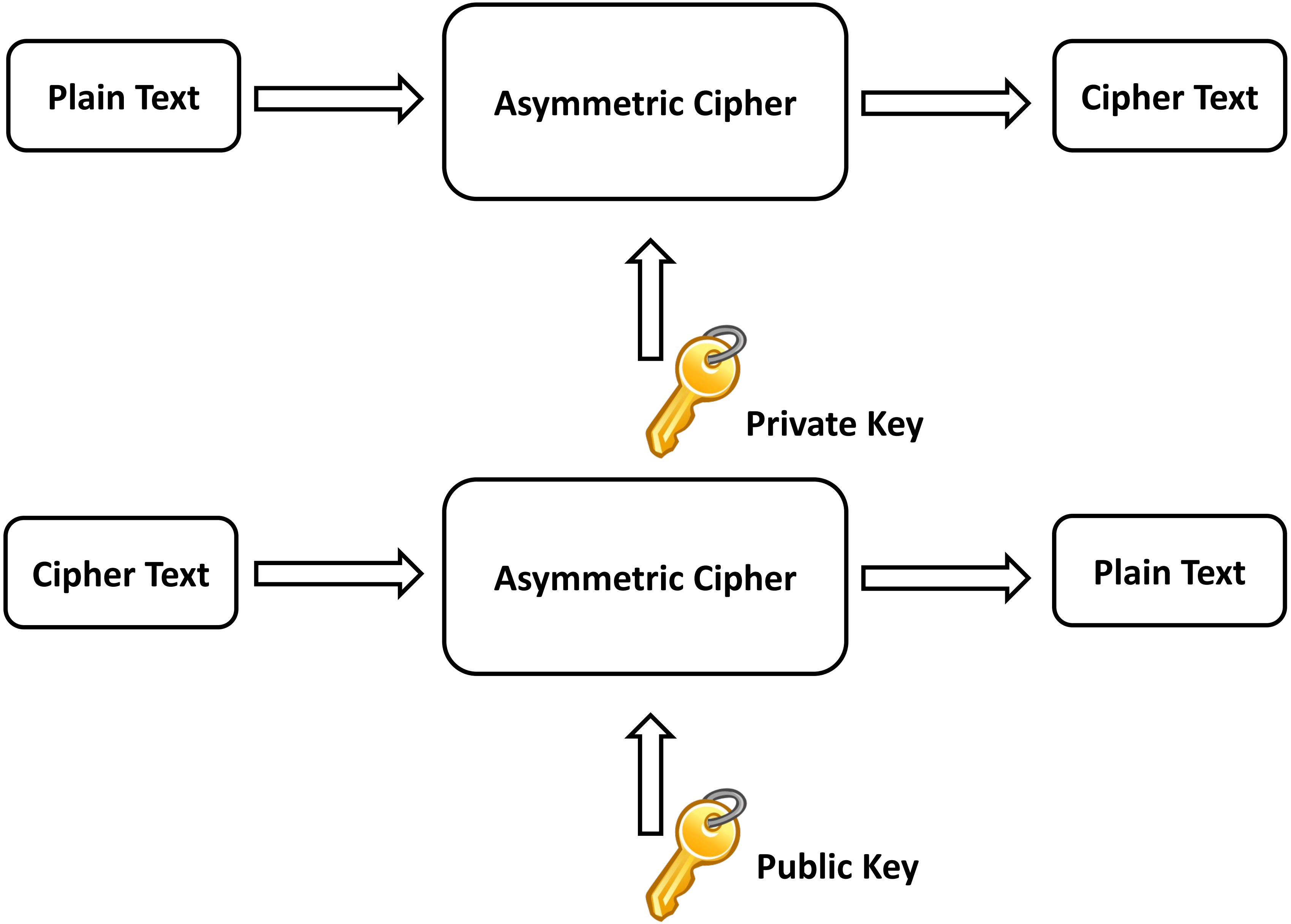


Sections of this Lecture

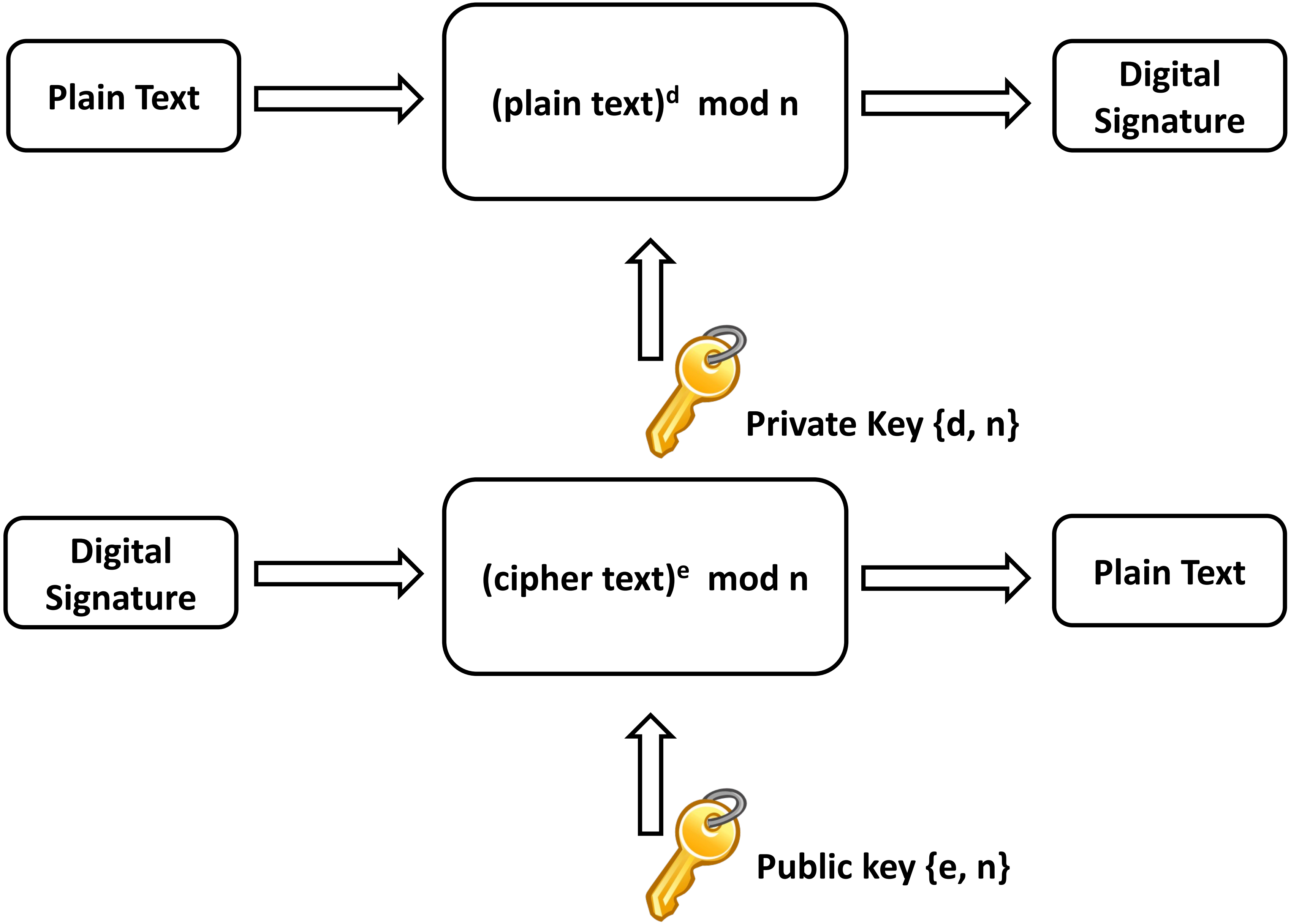
- Digital Signatures
- Cryptographic Hash Functions
- Passwords
- WannaCry

DIGITAL SIGNATURES

Digital Signing



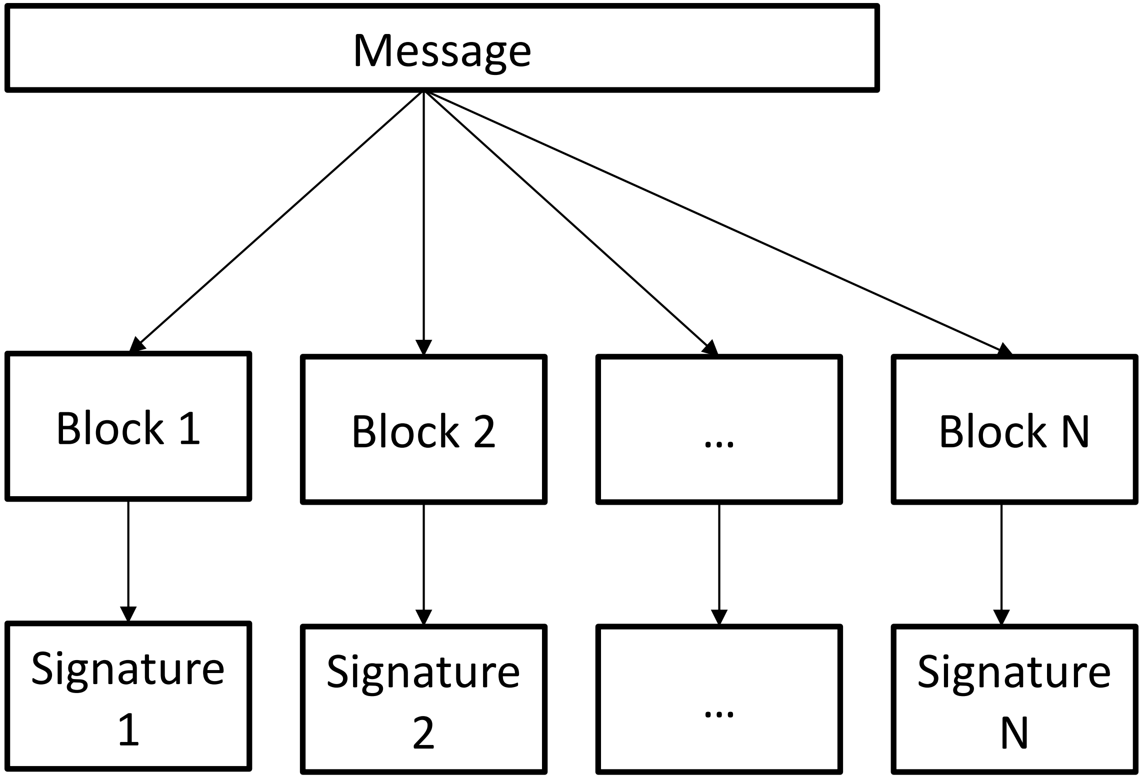
RSA


Plain Text
(plain text)^d mod n
Digital Signature
Private Key {d, n}
Digital Signature
(cipher text)^e mod n
Plain Text
Public key {e, n}

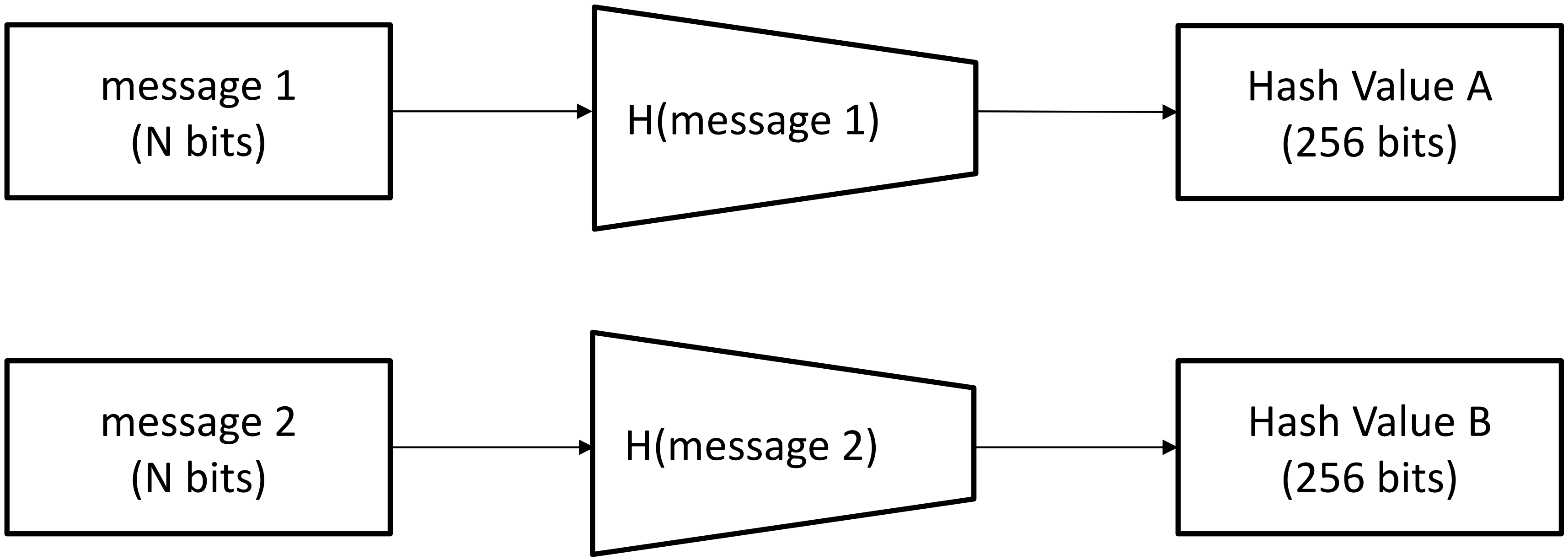
How do I digitally sign a large file?

- Naive solution: split the message in parts and sign each one of them

(1) Signature has the length of the message
(2) Computational overhead (several RSA computations)
(3) Security limitations

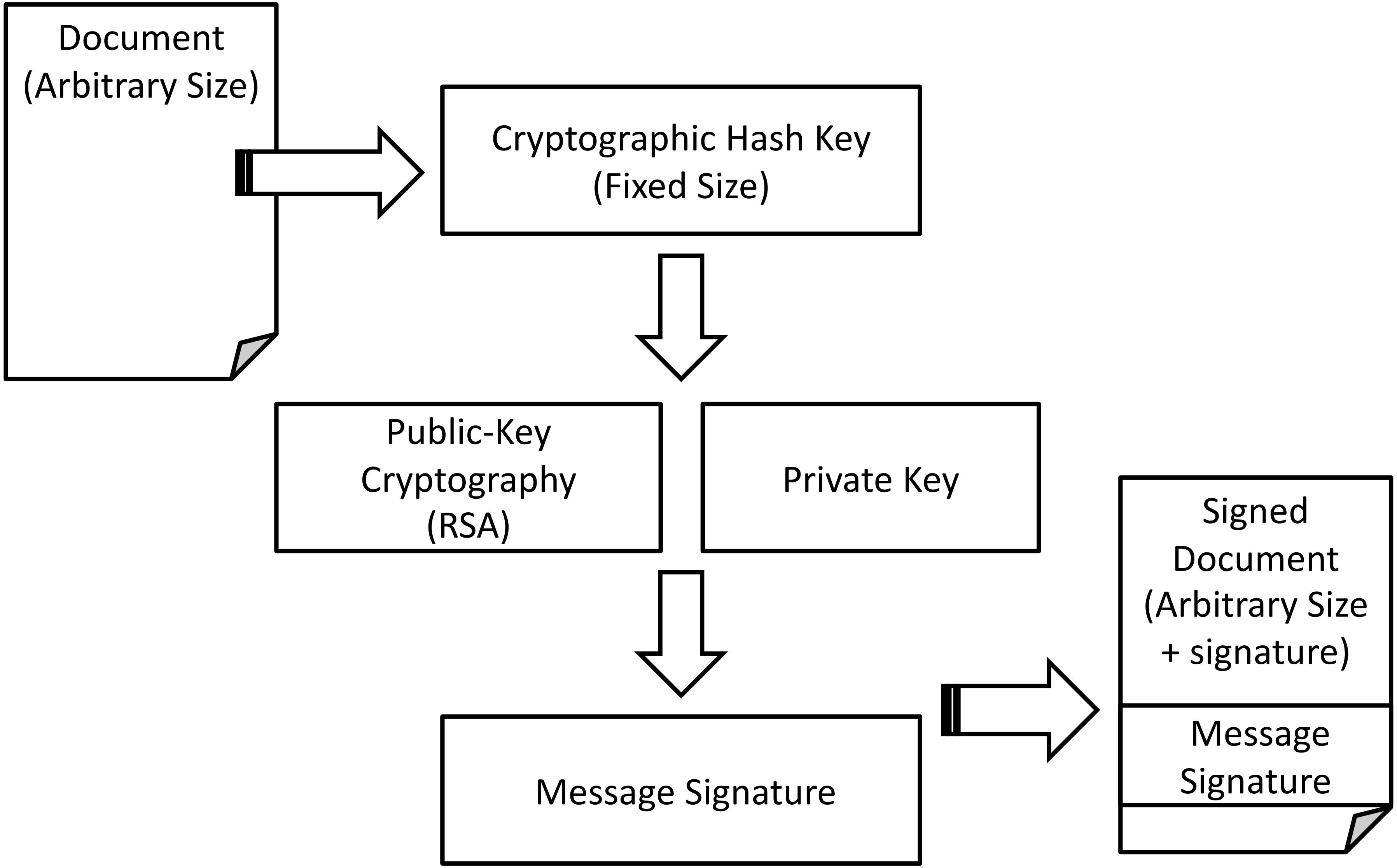


Cryptographic Hash Functions

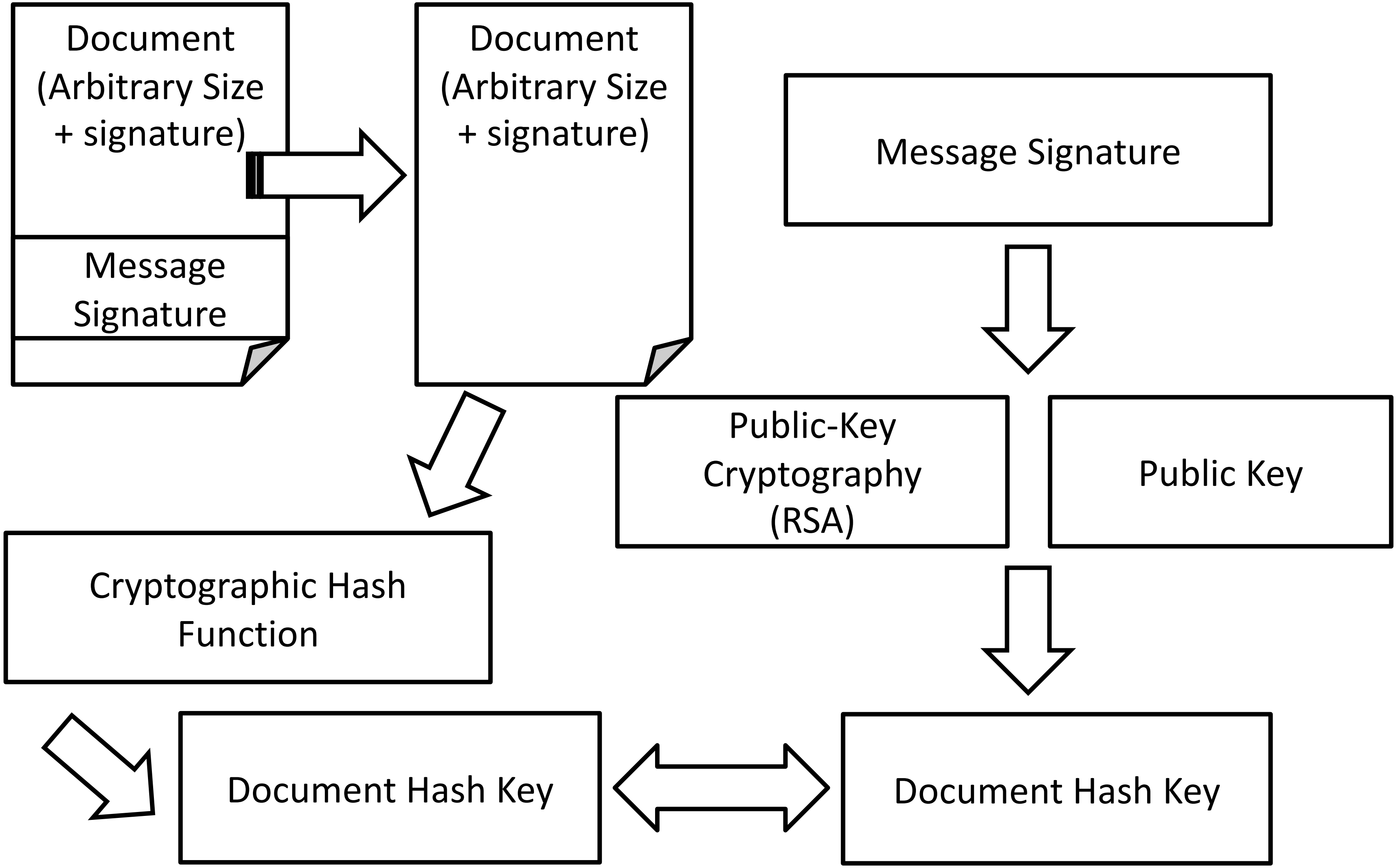


Ideally: If message 1 and message 2 differ by one bit, then A and B differ in 50% of their bits

Digital Signing

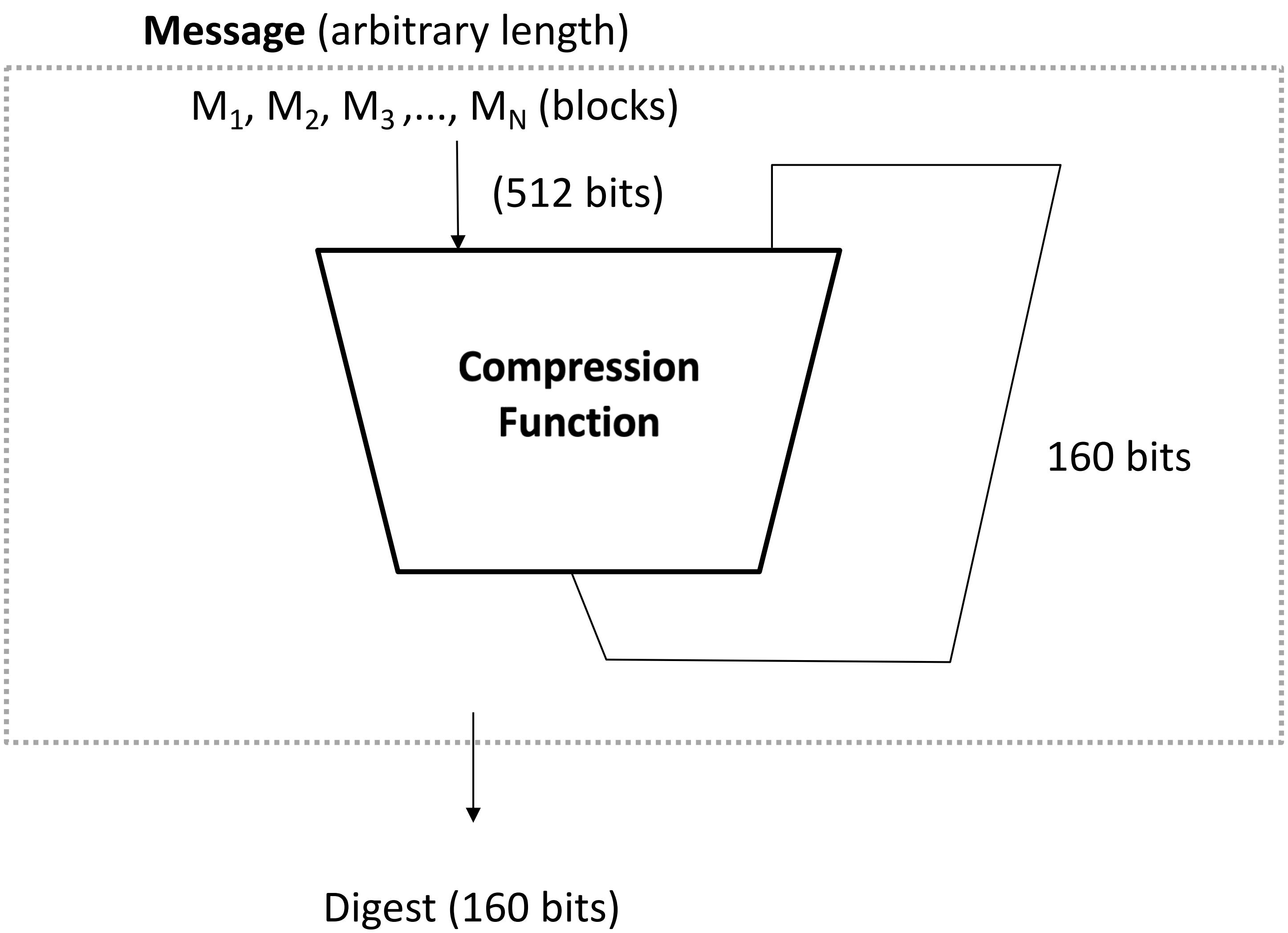


Verifying Digital Signatures



CRYPTOGRAPHIC HASH FUNCTIONS

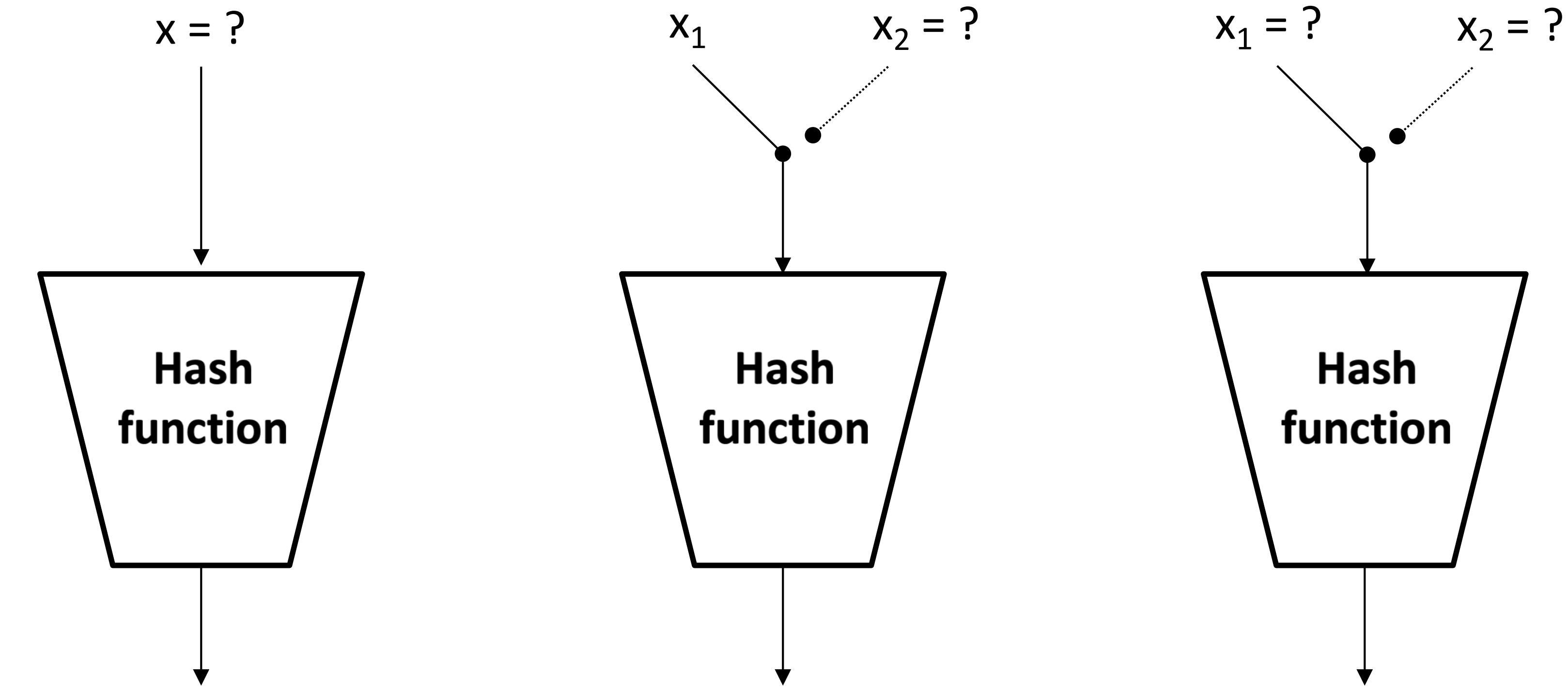
Merkle-Damgård Construction (SHA1)



High-level Properties

- Complicated **one-way** functions
- One-way
  - Hard to compute the message by having just the hash value (or *digest*)
  - No cryptographic keys
  - Should not be confused with invertible functions (1-1)
- Collision
  - Find a message that cryptographically hashes to a given digest H

Basic Requirements

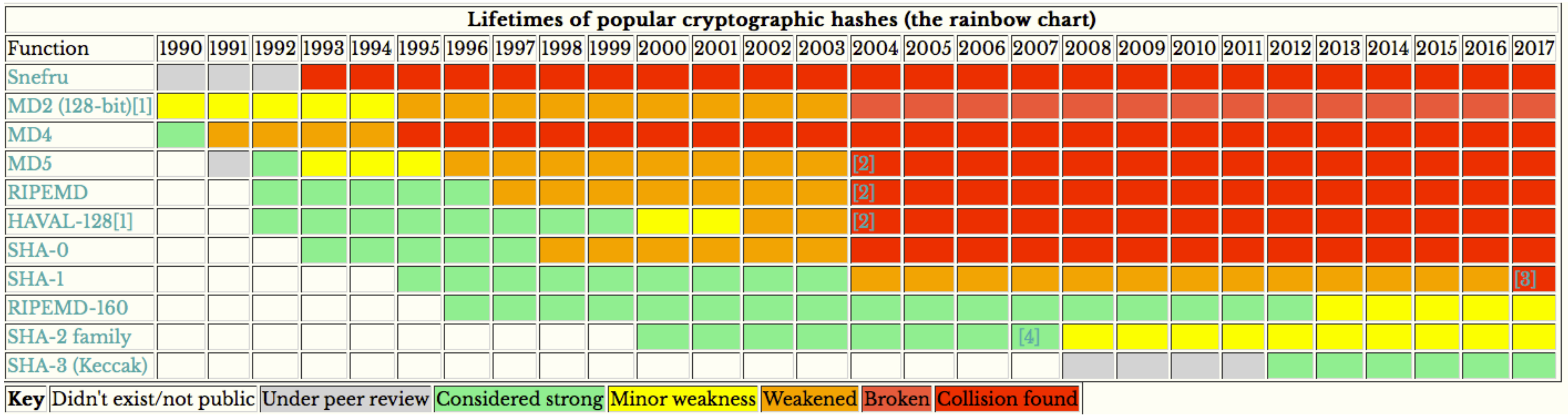


h(x)	$h(x_1) = h(x_2)$	$h(x_1) = h(x_2)$
preimage resistance	second preimage resistance	collision resistance

Basic Requirements

- Preimage Resistance (*“One way”*)
  - If you know just the *digest* it should be computationally hard to find a message M with the same *digest*
- Second Pre-image Resistance (*input resistance*)
  - Given a message M1, it should be computationally hard to find a second message, M2, with the same *digest*
- Collision resistance
  - It should be computationally hard to find any two messages, M1 and M2, with the same *digest*

Lifetimes of cryptographic hash functions



More: http://valerieaurora.org/hash.html

SHA256 is considered currently safe

PASSWORDS

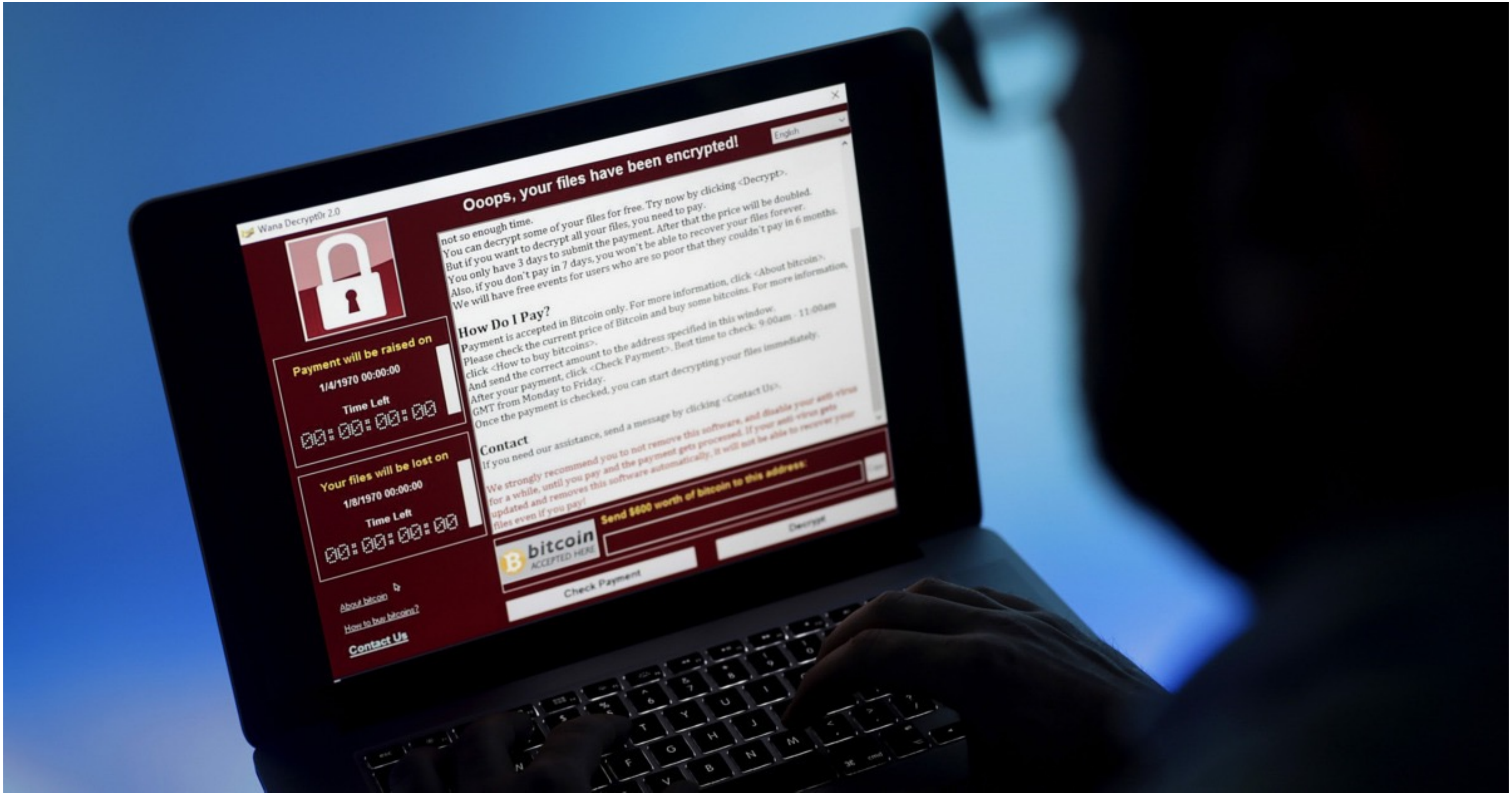
Other Uses - Passwords

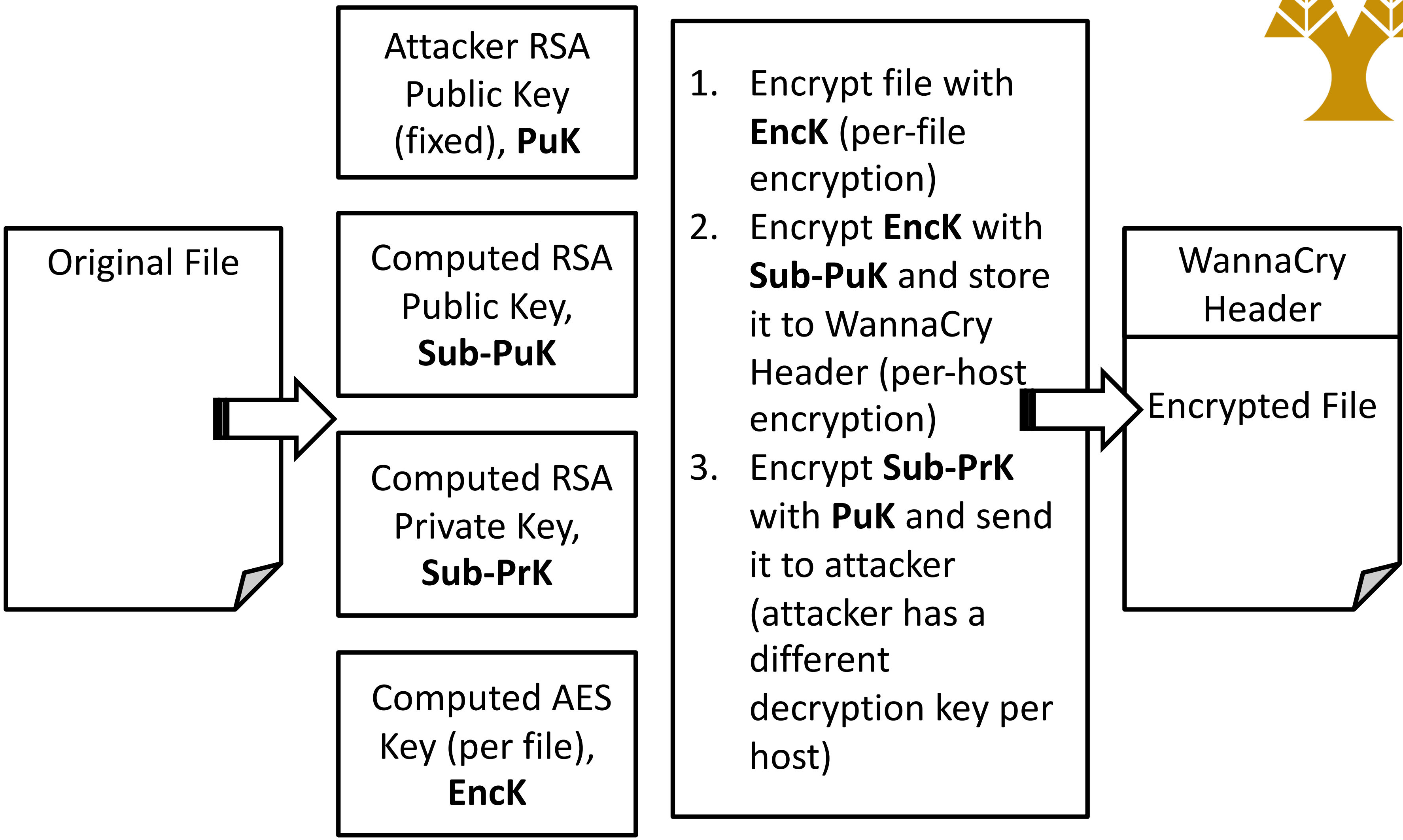
- Services
  - Store cryptographic hashes of passwords
  - Passwords in plaintext are deleted
- Authentication
  - Services compute and check cryptographic hashes and not plaintext passwords
- Encrypting passwords is a bad idea
  - Attacker can leak the key
- Passwords are *salted*
  - Identical plaintext passwords produce different hash keys

Attacking Passwords

- Brute force
- Dictionary attacks
- Rainbow tables
  - Salt can make this extremely hard
- GPUs

WANNACRY


Wana Decrypt0r 2.0
Ooops, your files have been encrypted!
English
not so enough time.
You can decrypt some of your files for free. Try now by clicking <Decrypt>.
But if you want to decrypt all your files, you need to pay.
You only have 3 days to submit the payment. After that the price will be doubled.
Also, if you don't pay in 7 days, you won't be able to recover your files forever.
We will have free events for users who are so poor that they couldn't pay in 6 months.
How Do I Pay?
Payment is accepted in Bitcoin only. For more information, click <About bitcoin>.
Please check the current price of Bitcoin and buy some bitcoins. For more information,
click <How to buy bitcoins>.
And send the correct amount to the address specified in this window.
After your payment, click <Check Payment>. Best time to check: 9:00am - 11:00am
GMT from Monday to Friday.
Once the payment is checked, you can start decrypting your files immediately.
Contact
If you need our assistance, send a message by clicking <Contact Us>.
Payment will be raised on
1/4/1970 00:00:00
Time Left
00:00:00:00
Your files will be lost on
1/8/1970 00:00:00
Time Left
00:00:00:00
Send $600 worth of bitcoin to this address:
bitcoin
ACCEPTED HERE
Check Payment
Decrypt
About bitcoin
How to buy bitcoins?
Contact Us



Read more: WannaKey, https://github.com/aguinet/wannakey

Resources

- This lecture was built using material that can be found at
  - Chapter 10 and 11, Understanding Cryptography, http://www.crypto-textbook.com
  - Chapter 9, 11, Handbook of Applied Cryptography, http://cacr.uwaterloo.ca/hac/
  - Chapter 6, 10, Serious Cryptography, https://nostarch.com/seriouscrypto