IT-Security (ITS) B1

DIKU, E2025

This is plain text

Computing in the presence of an adversary

This is not plain text

Cbzchgvat va gur cerfrapr bs na nqirefnel

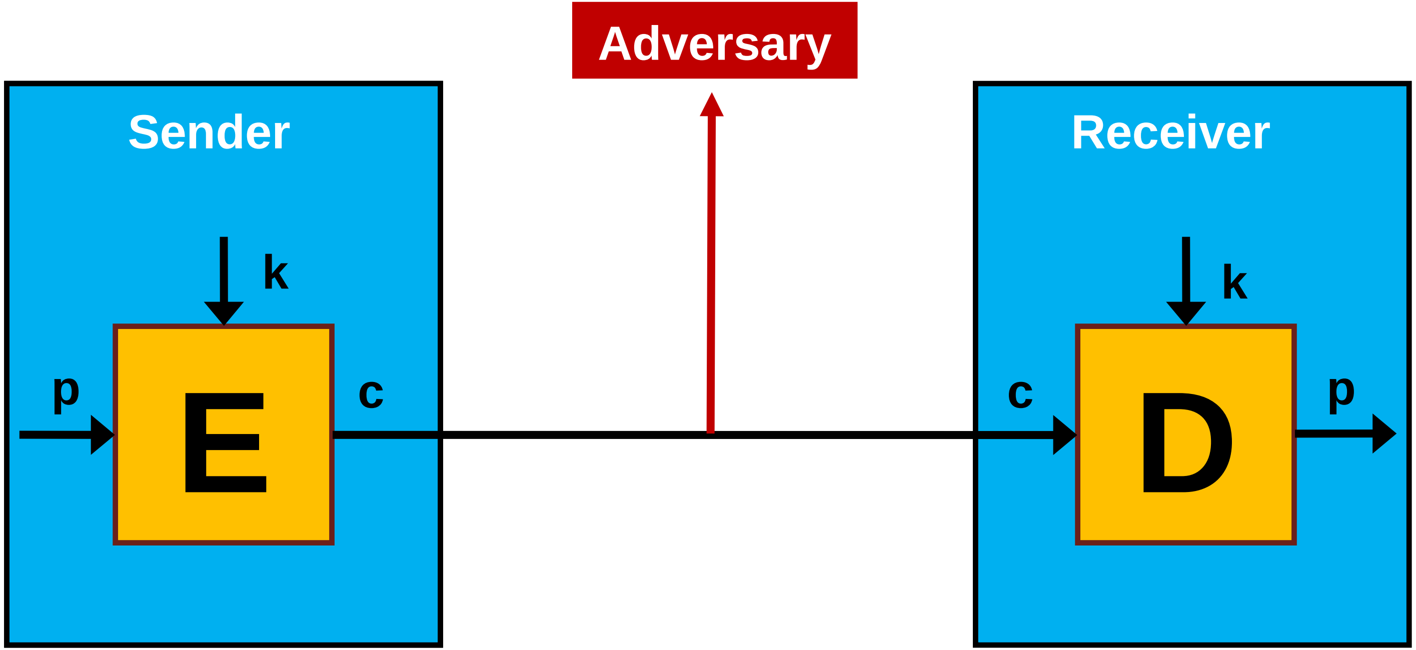
This is not plain text

Q29tcHV0aW5nIGluIHRoZSBwcmVzZW5jZSBvZiBhbiBhZHZlcnNhcnkK

This is not plain text

689b ef01 affa eb02 5618 7770 1c66 58ed 139c 9020 8431 2ff0 e7af
0d41 b3d5 b4a6 f222 90b3 f51a afd9 00fe e01d c509 69f4

Cryptosystems



Security goals

Confidentiality

Integrity

Authenticity

Non-repudiation

Today’s agenda

Part 1: Crypto building blocks

Part 2: More crypto building blocks

(Later: Real-world crypto protocols)

Today’s agenda

Cryptography defined

Cryptography from a historic perspective

Tools: Encryption, decryption, cryptographic hash functions, digital signatures,

(Cryptography is key, but hard to get right and not a panacea)

Crypto defined

Today’s agenda

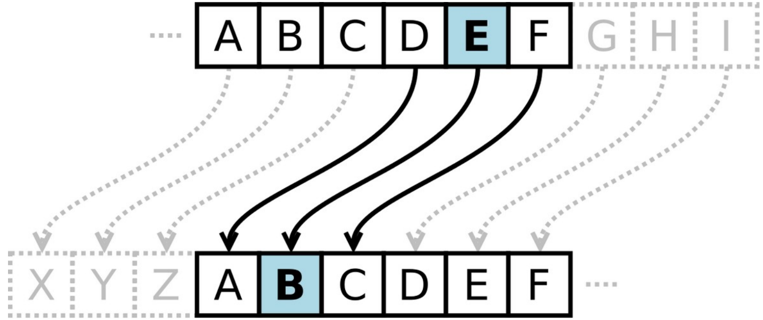
Cryptology (from Ancient Greek: kryptós "hidden, secret"; and graphein, "to write"), is the practice and study of codes, both creating and breaking them

Cryptography is the art of creating codes

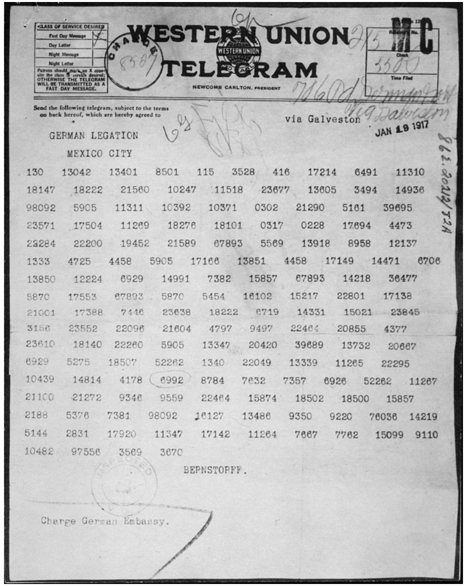
Cryptanalysis is the art of breaking codes

Crypto from a historic perspective

Cryptography influence world events



Cryptography influence world events



CLASS OF SERVICE DESIRED

Fast Day Message ☒

Day Letter □

Night Message □

Night Letter □

Patrons should mark an X opposite the class of service desired; OTHERWISE THE TELEGRAM WILL BE TRANSMITTED AS A FAST DAY MESSAGE.

CHARGE 8387

WESTERN UNION TELEGRAM

NEWCOMB CARLTON, PRESIDENT

Receiver's No. MC

Check 3300

Time Filed

Send the following telegram, subject to the terms on back hereof, which are hereby agreed to

via Galveston

JAN 19 1917

GERMAN LEGATION

MEXICO CITY

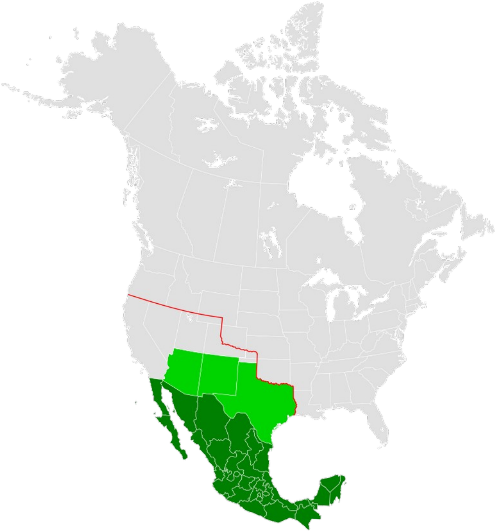
```
130    13042  13401  8501   115    3528   416    17214  6491   11310
18147  18222  21560  10247  11518  23677  13605  3494   14936
98092  5905   11311  10392  10371  0302   21290  5161   39695
23571  17504  11269  18276  18101  0317   0228   17694  4473
22284  22200  19452  21589  67893  5569   13918  8958   12137
1333   4725   4458   5905   17166  13851  4458   17149  14471  6706
13850  12224  6929   14991  7382   15857  67893  14218  36477
5870   17553  67893  5870   5454   16102  15217  22801  17138
21001  17388  7446   23638  18222  6719   14331  15021  23845
3156   23552  22096  21604  4797   9497   22464  20855  4377
23610  18140  22260  5905   13347  20420  39689  13732  20667
6929   5275   18507  52262  1340   22049  13339  11265  22295
10439  14814  4178   6992   8784   7632   7357   6926   52262  11267
21100  21272  9346   9559   22464  15874  18502  18500  15857
2188   5376   7381   98092  16127  13486  9350   9220   76036  14219
5144   2831   17920  11347  17142  11264  7667   7762   15099  9110
10482  97556  3569   3670
```

BERNSTORFF.

INSPECTED

Charge German Embassy.

862.20212/82A



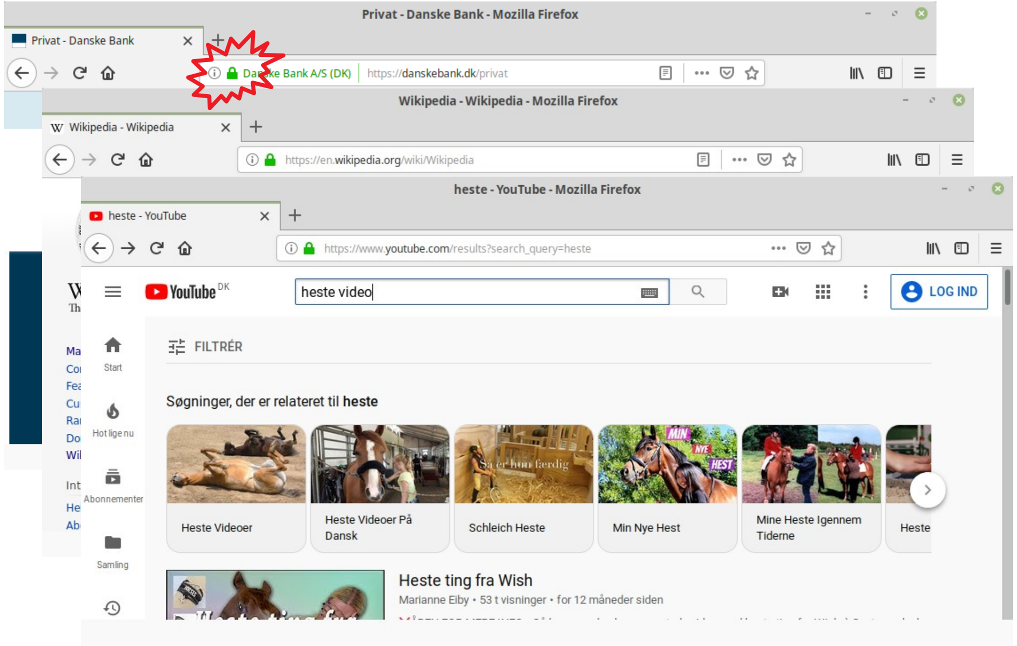
ZIMMERMANN NOTE

EXPLODING IN HIS HANDS.

—Kirby in the New York *World*.

Cryptography influence world events

Our goal: Secure online communication



Privat - Danske Bank - Mozilla Firefox
Privat - Danske Bank
Danske Bank A/S (DK)
https://danskebank.dk/privat
Wikipedia - Wikipedia - Mozilla Firefox
Wikipedia - Wikipedia
https://en.wikipedia.org/wiki/Wikipedia
heste - YouTube - Mozilla Firefox
heste - YouTube
https://www.youtube.com/results?search_query=heste
YouTube DK
heste video
LOG IND
Start
Hot lige nu
Abonnementer
Samling
FILTRÉR
Søgninger, der er relateret til heste
Heste Videoer
Heste Videoer På Dansk
Schleich Heste
Min Nye Hest
Mine Heste Igennem Tiderne
Heste
Heste ting fra Wish
Marianne Eiby • 53 t visninger • for 12 måneder siden

Warm-up question

FileCrypt

“**FileCrypt** is a dynamic non-factor based quantum AI encryption hardware solution.

Developed by our cryptographic experts and hardwired into a tamper-resistant USB token.

Plug the token into your PC, start the program and encrypt the files you need to protect”

What problems do you see with this solution?

Multiple concerns

#1: “Developed by our cryptographic experts”

Should we trust proprietary crypto over public peer-reviewed time-tested crypto?

#2: “Dynamic non-factor based quantum AI”

What does that mean? Are there any academic papers that discuss this concept?

#3: “Plug the token into your PC”

Can anyone do this? What if token is lost? Violates **Kerckhoffs’ Principle**

Kerckhoffs’ (2nd) Principle

The security of a cryptographic algorithm must rest solely in the secrecy of its **key**, not in the secrecy of the algorithm itself

Collaries:

Assume attacker knows the algorithm
Make it available for public analysis
Protect the key!

Auguste Kerckhoffs
(1835 – 1903)

Symmetric cryptosystems

Symmetric cryptosystems

Stream ciphers

One time pad

If *k* random, |*k*| >= |*p*|, never reused, and kept secret, then then impossible to decrypt or break without knowing the key (Shannon, 1949)

Key	0	1	0	1	1	1	0	0	1	0
Plaintext	1	1	0	0	0	1	1	0	0	0
Ciphertext	1	0	0	1	1	0	1	0	1	0

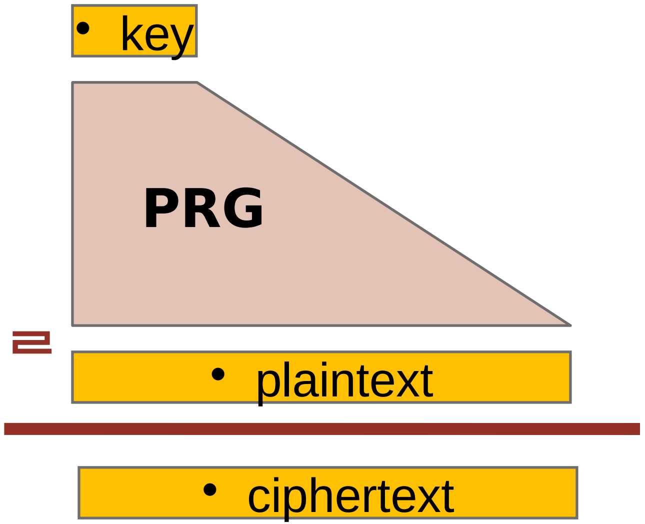
Towards modern stream ciphers

Problem

OTP key as long as plaintext

Solution

Generate pseudo random keystream



1st rule of stream ciphers

Never reuse key

$$C_1 \leftarrow P_1 \oplus PRG(k)$$

$$C_2 \leftarrow P_2 \oplus PRG(k)$$

$$C_1 \oplus C_2 \rightarrow P_1 \oplus P_2$$

$$P_1 \oplus P_2 \rightarrow P_1, P_2$$

Solution: Initialisation Vector (IV)

For each message

- Generate IV
- Mix k with IV
- Generate keystream PRG(k+IV) and encrypt
- Send c and IV (in plaintext)

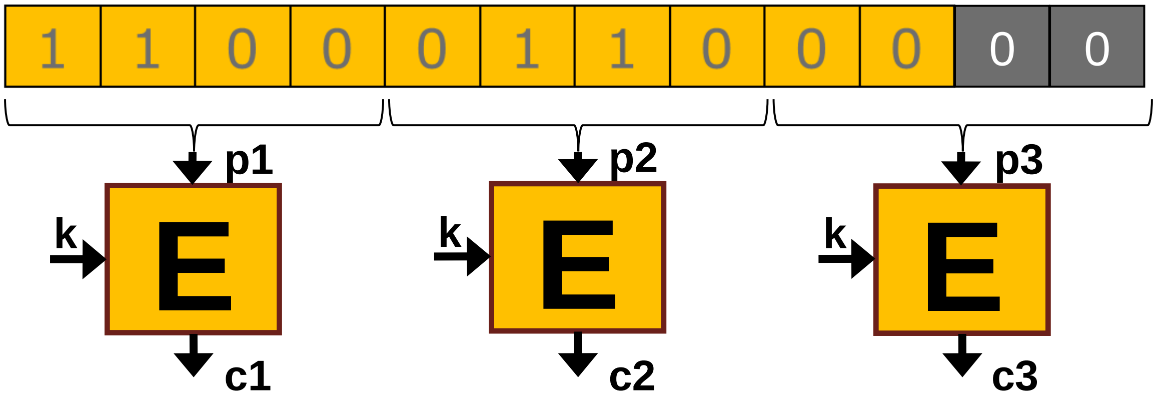
Change k before IVs run out

Block ciphers

Block ciphers

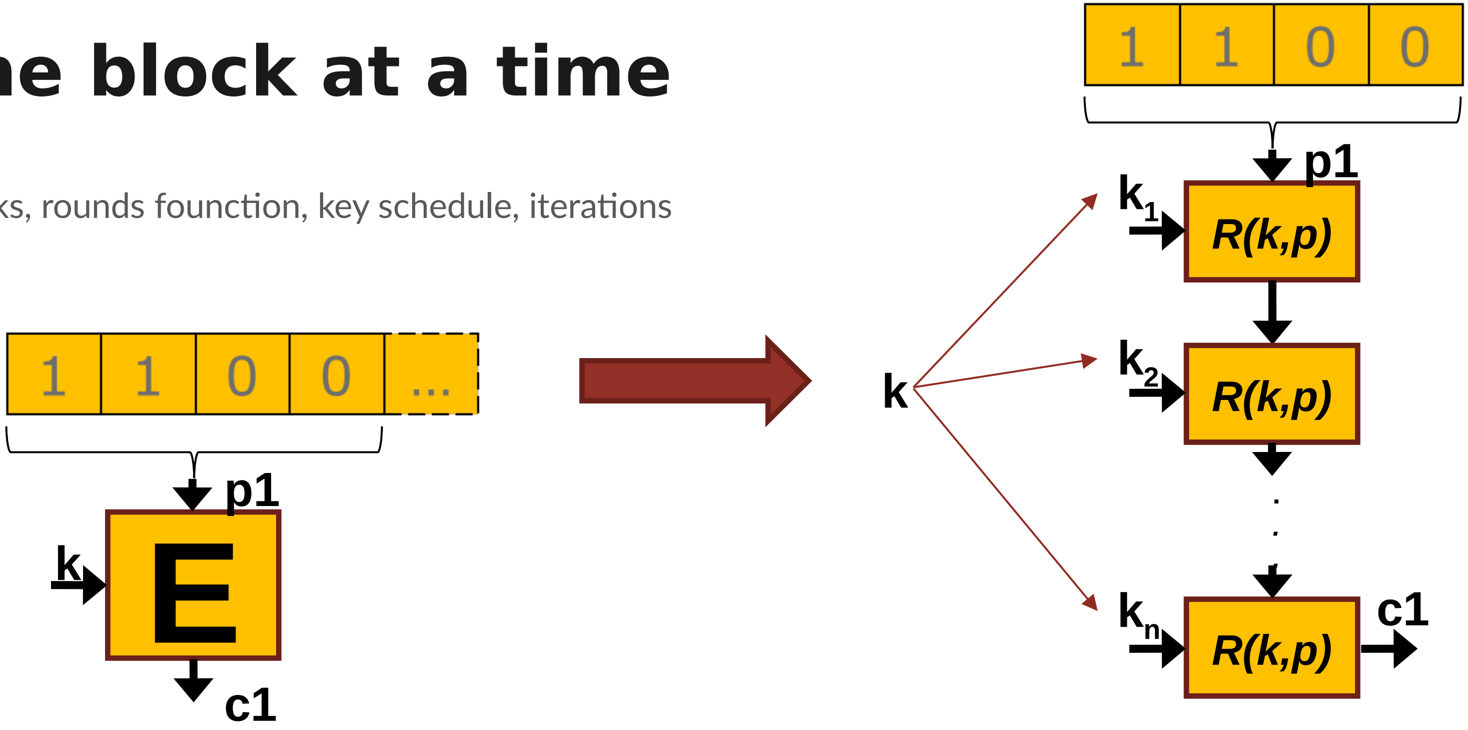
One block at a time – as oppossed to one bit at a time

- **padding**



One block at a time

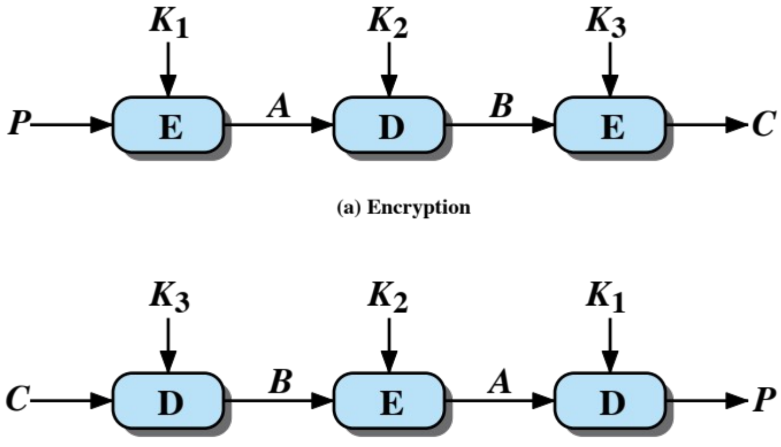
Blocks, rounds founction, key schedule, iterations



DES

DES

Key 64, block 64, rounds 16



(a) Encryption

(b) Decryption

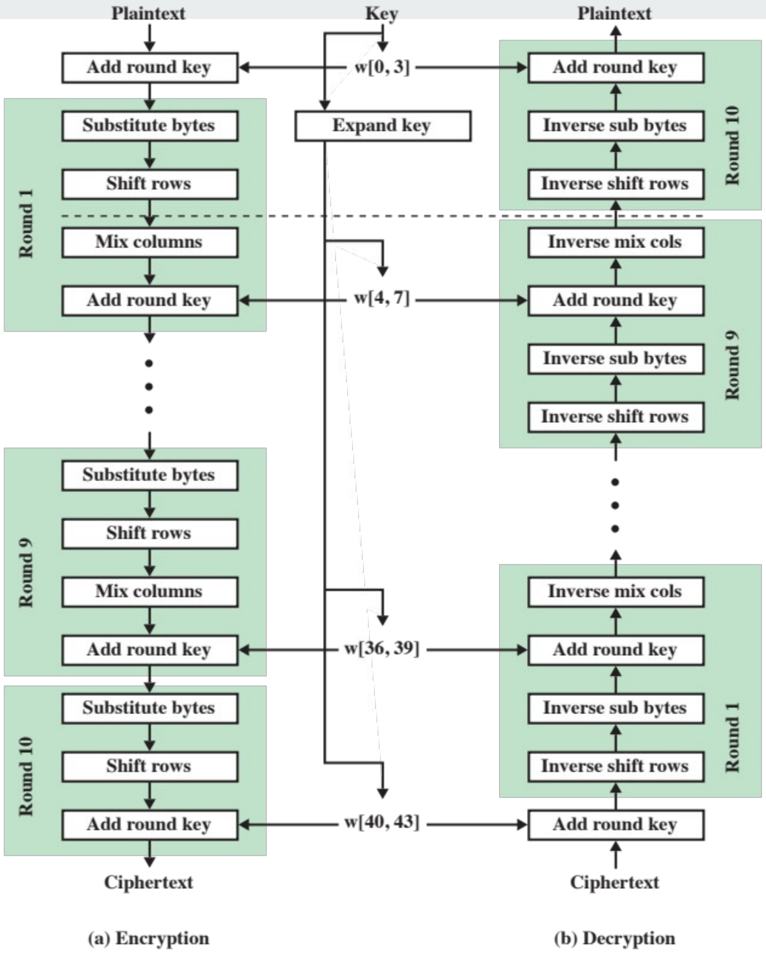
AES

AES

Keys 128/192/256

Block 128

Rounds 10/12/14

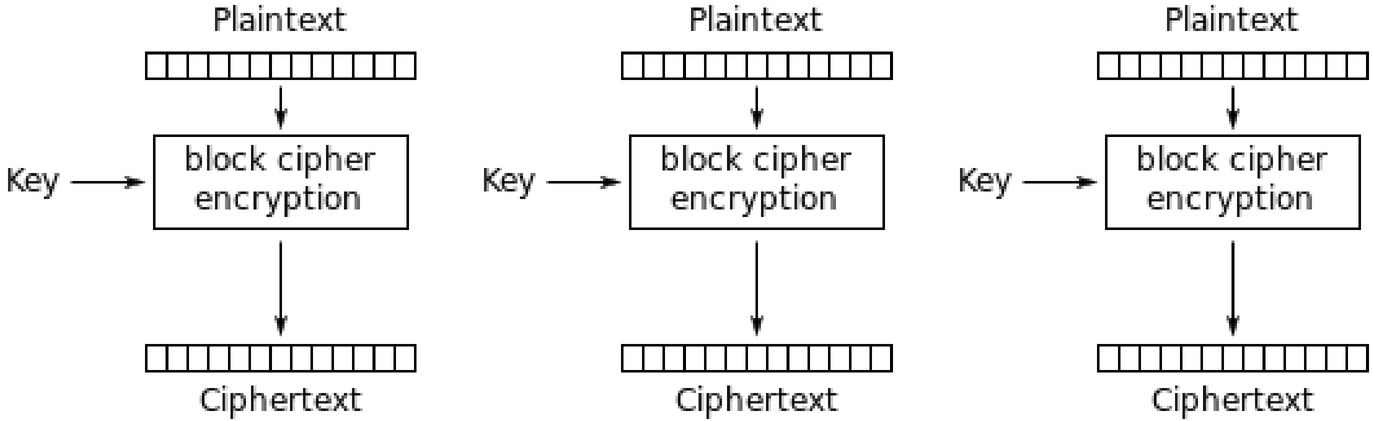


(a) Encryption

(b) Decryption

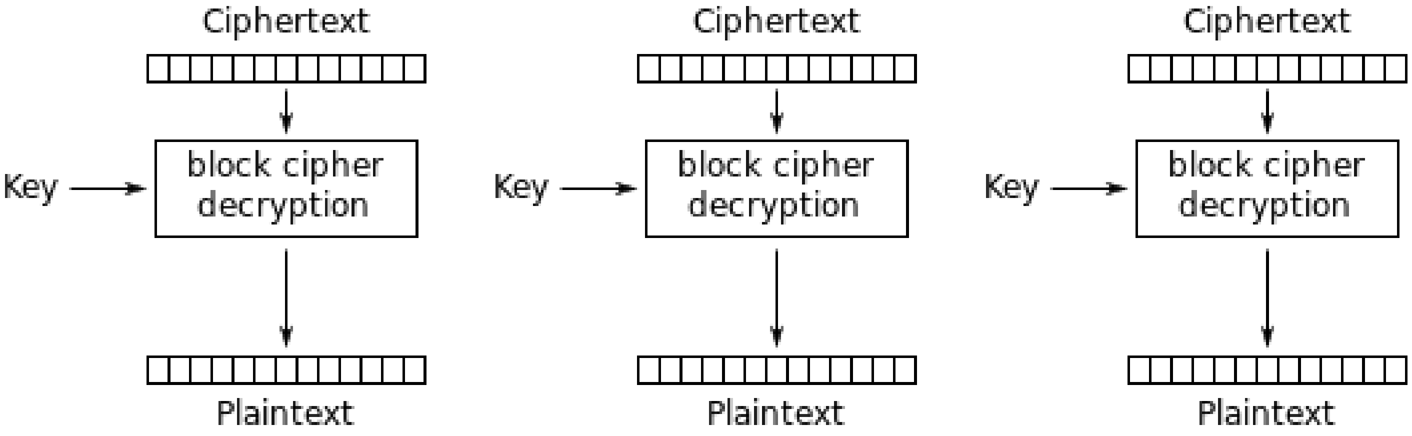
Modes of operation

Electronic Codebook (ECB)



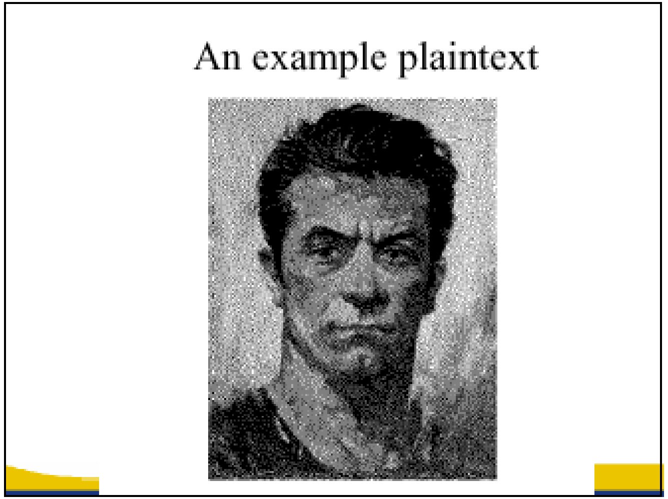
Electronic Codebook (ECB) mode encryption

ECB decyption

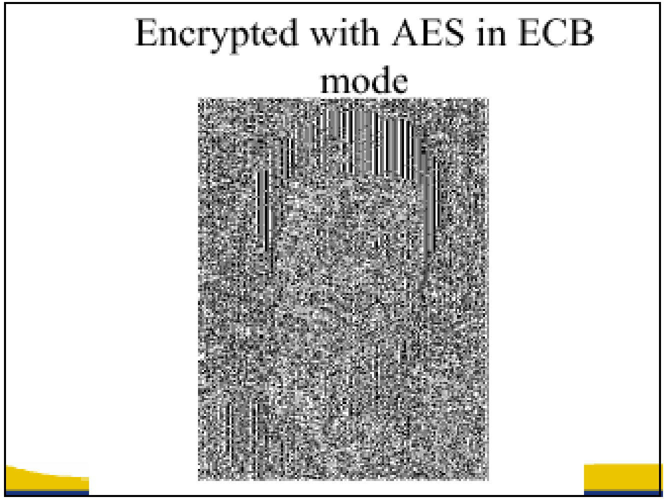


Electronic Codebook (ECB) mode decryption

If p1 = p2, then c1 = c2

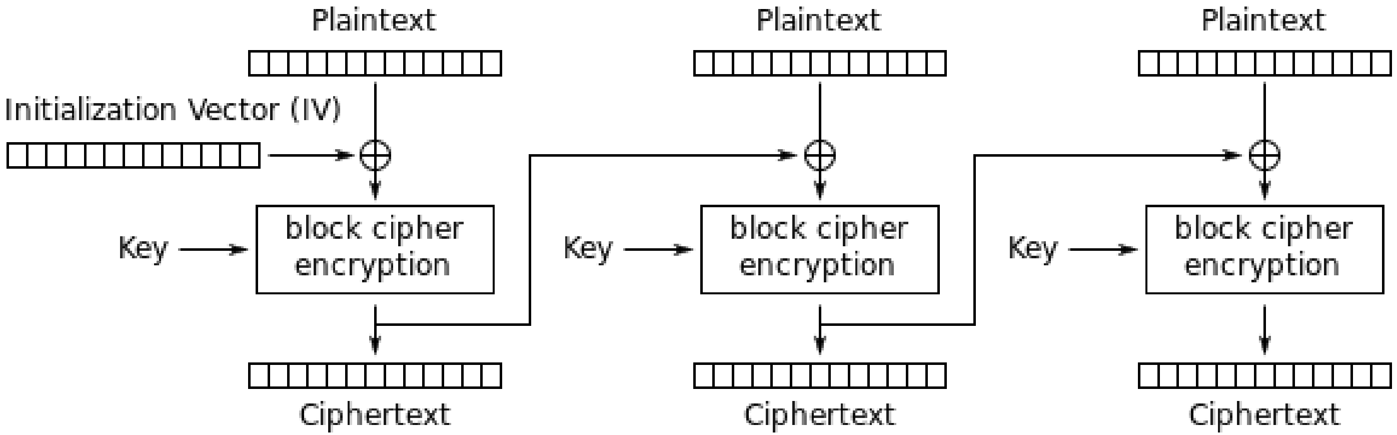


An example plaintext



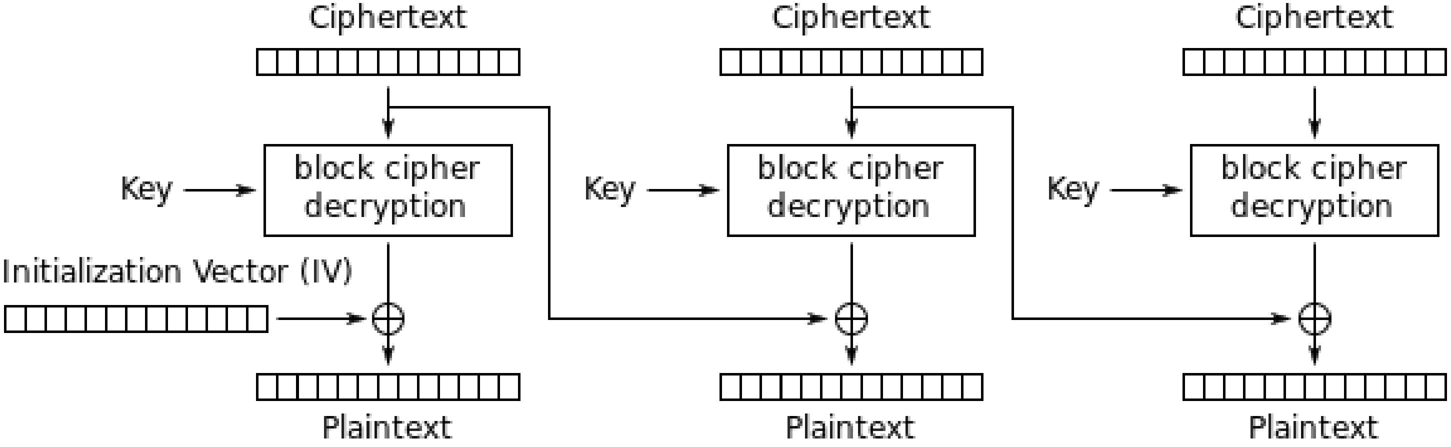
Encrypted with AES in ECB mode

Cipher Block Chaining



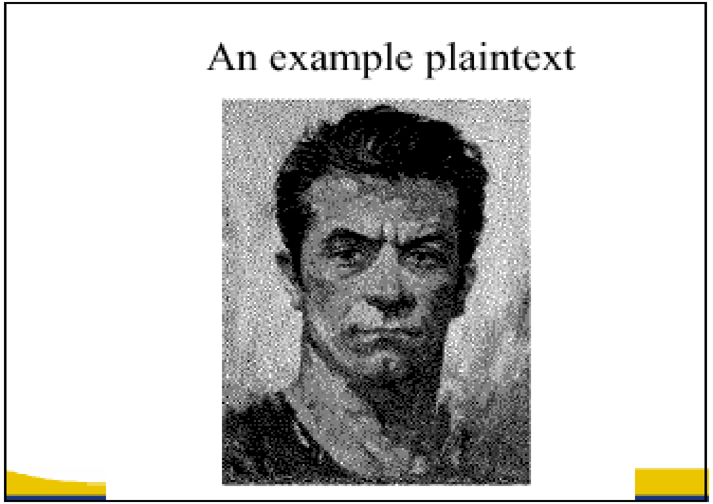
Cipher Block Chaining (CBC) mode encryption

CBC decryption

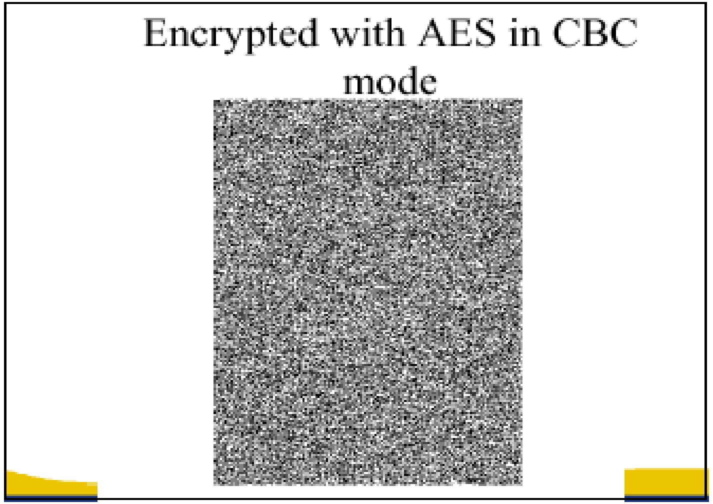


Cipher Block Chaining (CBC) mode decryption

Better

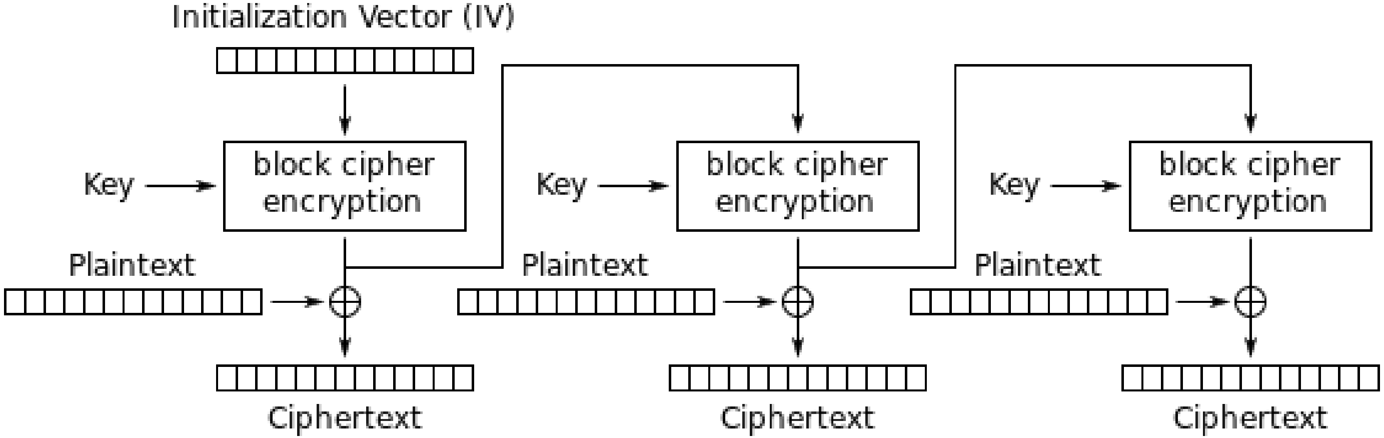


An example plaintext



Encrypted with AES in CBC mode

Output Feedback



Output Feedback (OFB) mode encryption

Security goals revisited

“Susceptibility to malicious insertions and modifications. Because each symbol is separately enciphered, an active interceptor who has broken the code can splice together pieces of previous messages and transmit a spurious new message that may look authentic.” - Phleeger & Phleeger in Security in Computing, Pearson, 2003

Is this a disadvantage of stream cipher? Why, why not?

Security goal of encryption: Confidentiality

Status

Confidentiality: Check!

Integrity: Missing

Message authentication code (MAC)

Message authentication code

Goal: Provide integrity

Process

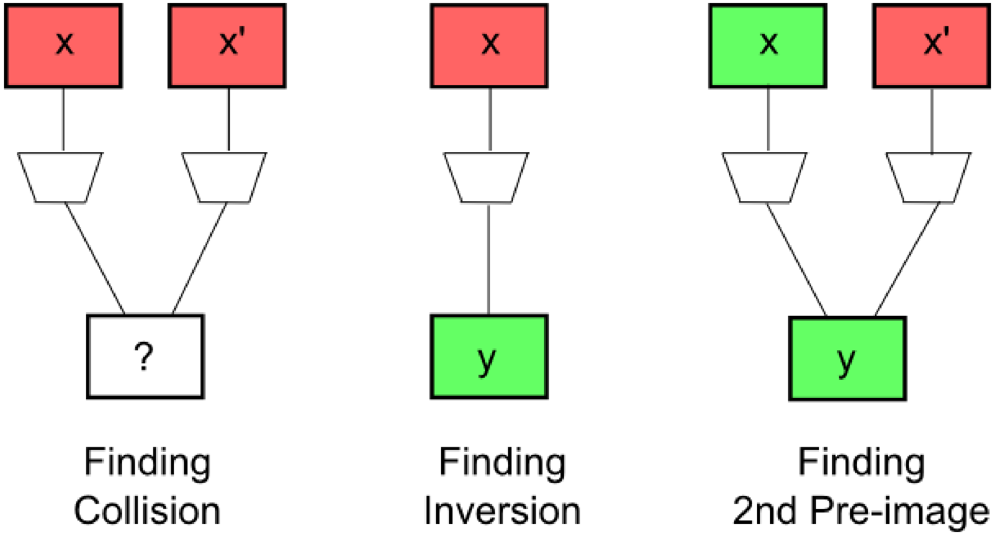
Choose a cryptographic hash function h : $\{0,1\}^x$ -> $\{0,1\}^n$

Sender: Send h(m),m

Receiver: Calculate h(m) and verify it matches h(m)

Examples MD5 (n = 128), SHA-256 (n = 256)

Cryptographic hash functions



Hash-based MAC (HMAC)

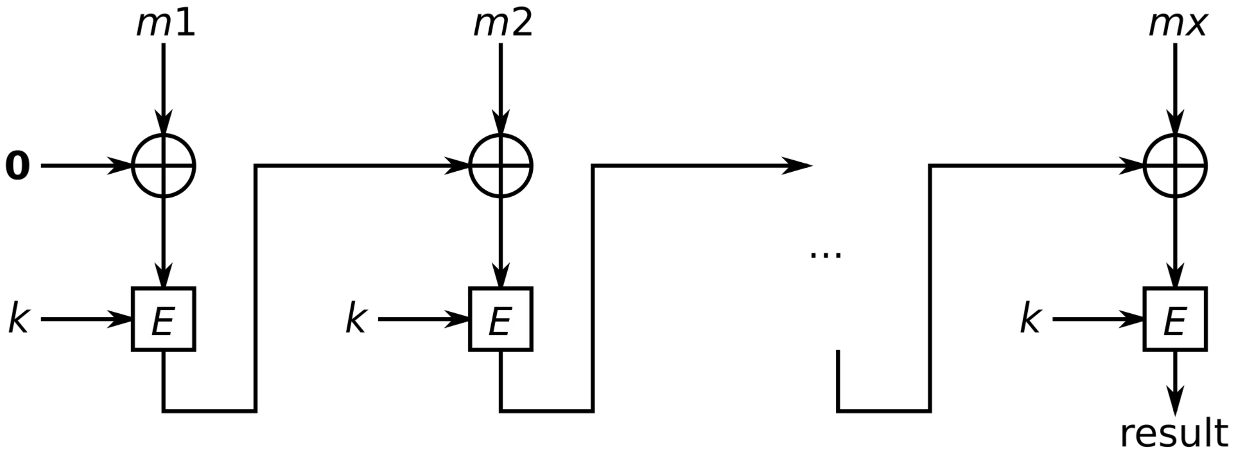
RFC2104: Hash-based MAC

HMAC(h,k,m) =

$$h\ (\ (k \oplus opad) \parallel h\ ((k \oplus ipad) \parallel m)$$

HMAC provides integrity and authenticity

CBC-MAC



Car keys

Your car key sends the code for ”open the door”, together with a MAC, to the car whenever you press the button.

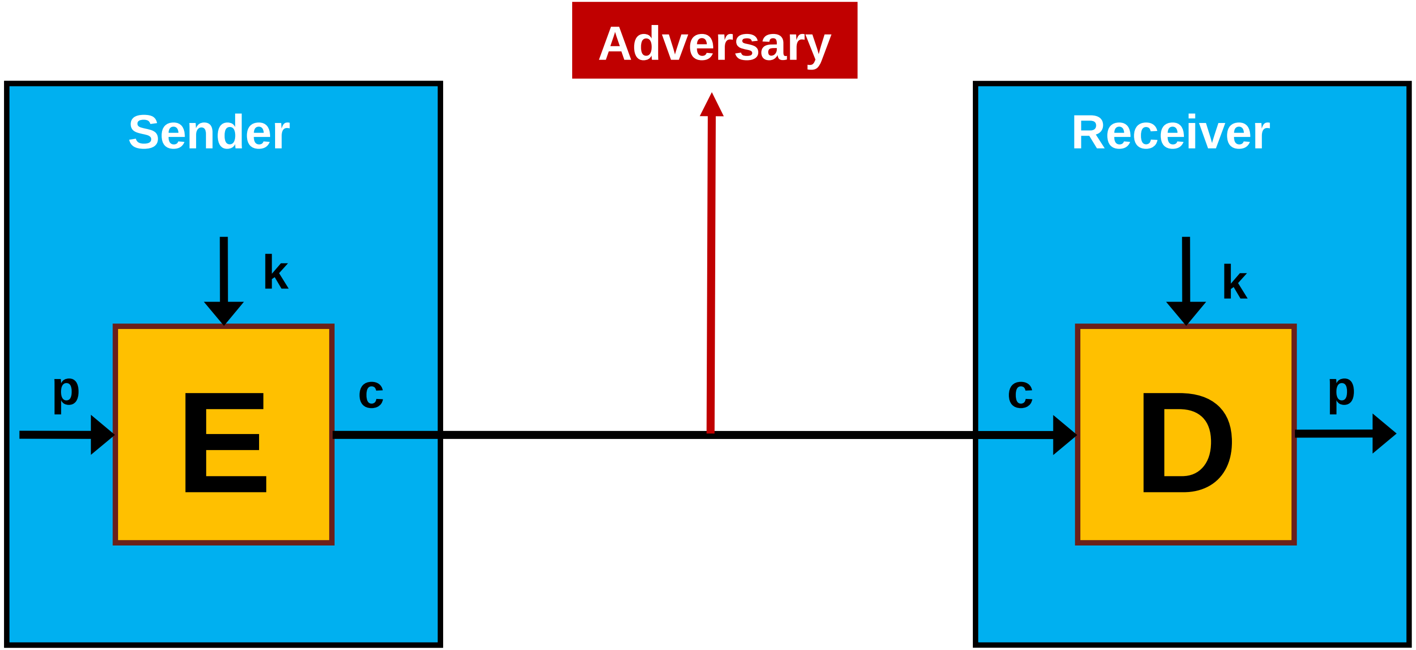
What could go wrong?

Replay attack: attacker records message and replays it later

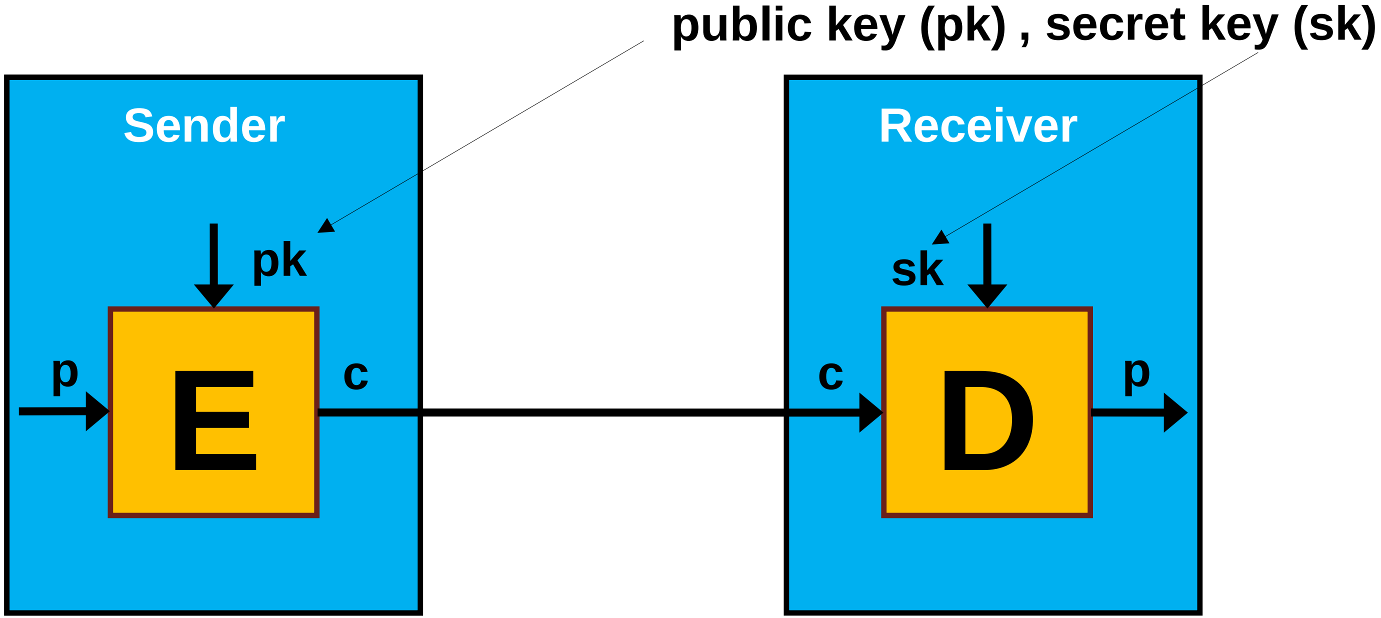
We need some freshness: a timestamp or nonce

Non-repudiation

Cryptosystems



Enter: Asymmetric encryption



Analogy: Combination locks

Bob sends out locks with combination he only knows

Alice picks one of Bob's locks, places her message in a box and locks it with Bob's lock

Bob is the only one who can open the box now

No pre-shared key!

Bob

Publish public key, protect private key

Alice

Encrypt message with Bob’s public key

Bob

Decrypts with his private key

Rivest Shamir Adleman (RSA), 1978

First asymmetric cryptosystem

RSA encryption and decryption

Public key (N,e), private key (d)

$C = M^e \pmod N$

$M = C^d \pmod N$

Asymmetric encryption: Yes! But what about non-repudiaton?

Reverse

Public key (N,e), private key (d)

Signature sig(M) = M^d (mod N)

Verify ver(M,sig(M)) = true iff M = $(M^d)^e$ (mod N)

Wrap-up

Security goals achieved

Confidentiality

Integrity

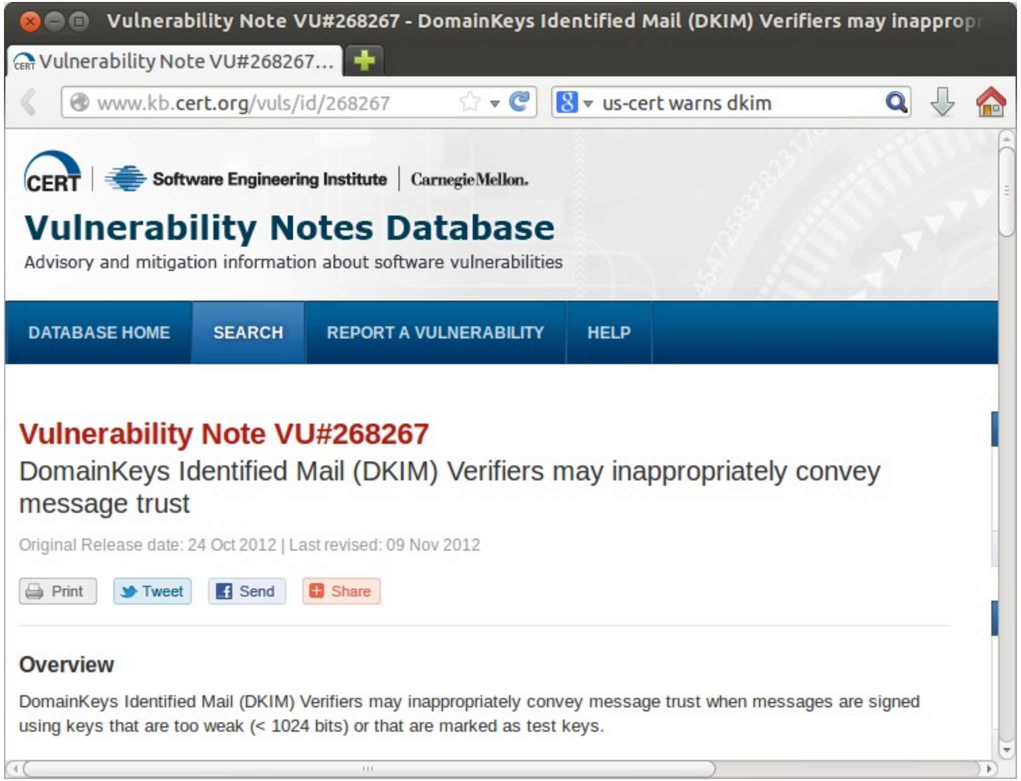
Authenticity

Non-repudiation

CHECK!

But crypto can still fail

Small keys fail


Vulnerability Note VU#268267 - DomainKeys Identified Mail (DKIM) Verifiers may inapprop
Vulnerability Note VU#268267...
www.kb.cert.org/vuls/id/268267
us-cert warns dkim
CERT
Software Engineering Institute
CarnegieMellon.
DATABASE HOME
SEARCH
REPORT A VULNERABILITY
HELP
Print
Tweet
Send
Share

Vulnerability Notes Database

Advisory and mitigation information about software vulnerabilities

Vulnerability Note VU#268267

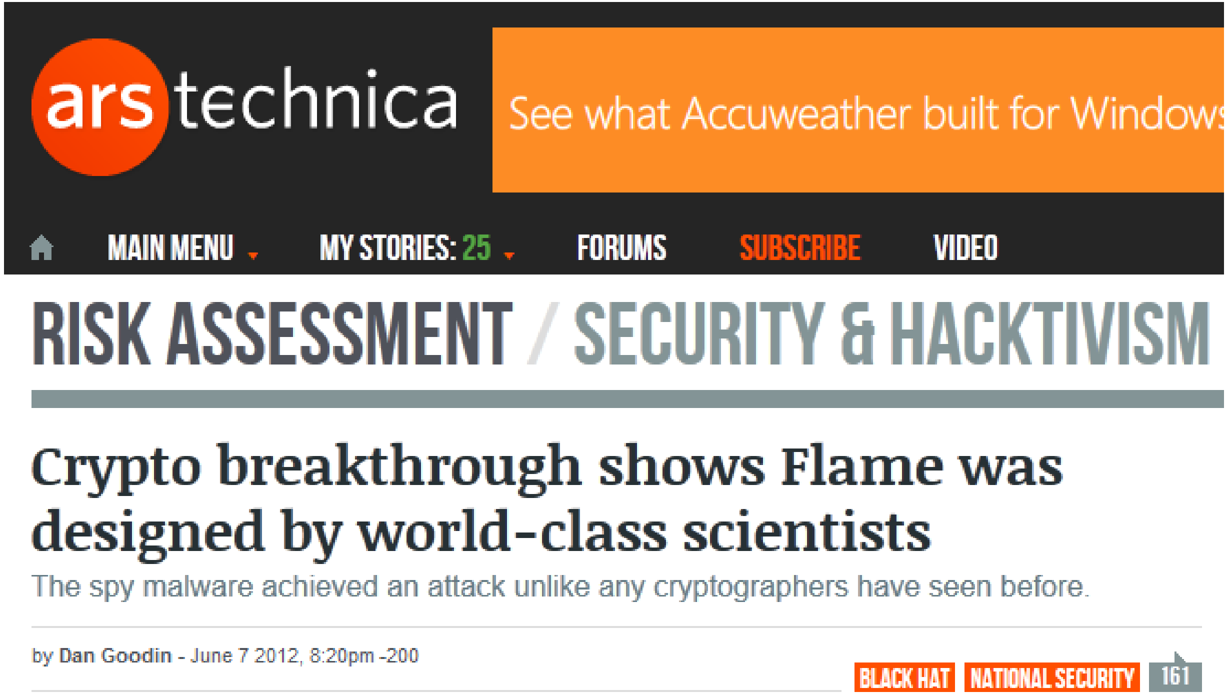
DomainKeys Identified Mail (DKIM) Verifiers may inappropriately convey message trust

Original Release date: 24 Oct 2012 | Last revised: 09 Nov 2012

Overview

DomainKeys Identified Mail (DKIM) Verifiers may inappropriately convey message trust when messages are signed using keys that are too weak (< 1024 bits) or that are marked as test keys.

Collision fail

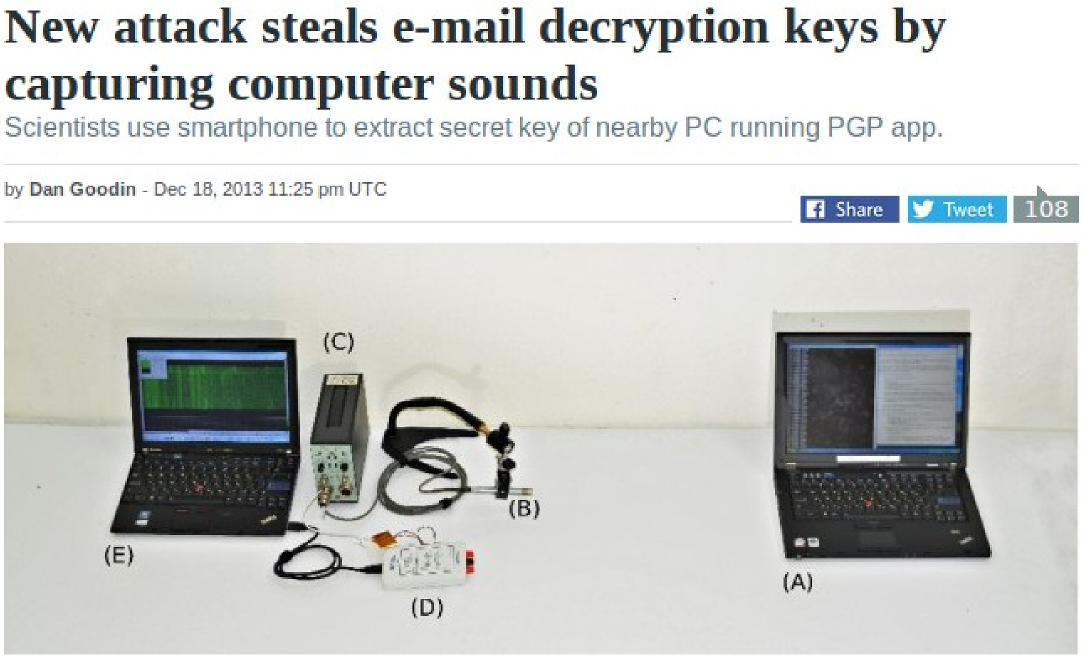


Crypto breakthrough shows Flame was designed by world-class scientists

The spy malware achieved an attack unlike any cryptographers have seen before.

by Dan Goodin - June 7 2012, 8:20pm -200

Impressive fail

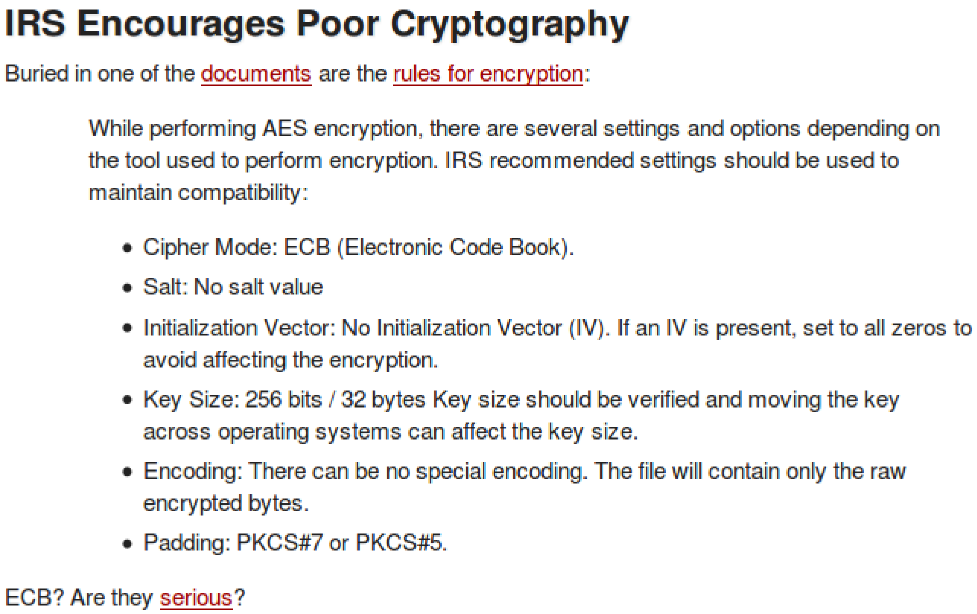


New attack steals e-mail decryption keys by capturing computer sounds

Scientists use smartphone to extract secret key of nearby PC running PGP app.

by **Dan Goodin** - Dec 18, 2013 11:25 pm UTC

Bad choice fail



IRS Encourages Poor Cryptography

Buried in one of the documents are the rules for encryption:

> While performing AES encryption, there are several settings and options depending on the tool used to perform encryption. IRS recommended settings should be used to maintain compatibility:
>
> - Cipher Mode: ECB (Electronic Code Book).
> - Salt: No salt value
> - Initialization Vector: No Initialization Vector (IV). If an IV is present, set to all zeros to avoid affecting the encryption.
> - Key Size: 256 bits / 32 bytes Key size should be verified and moving the key across operating systems can affect the key size.
> - Encoding: There can be no special encoding. The file will contain only the raw encrypted bytes.
> - Padding: PKCS#7 or PKCS#5.

ECB? Are they serious?

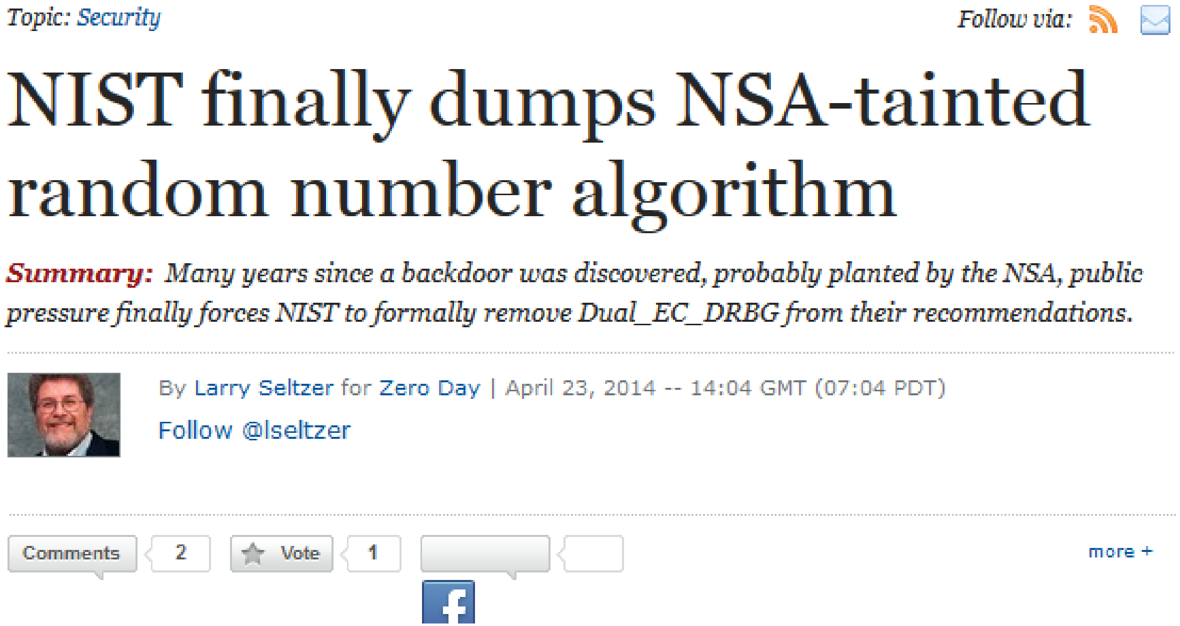
DIY fail

Smart grid security WORSE than we thought

OSGP's DIY MAC is a JOKE

11 May 2015 at 02:03, Richard Chirgwin

Backdoor fail



Topic: Security

Follow via:

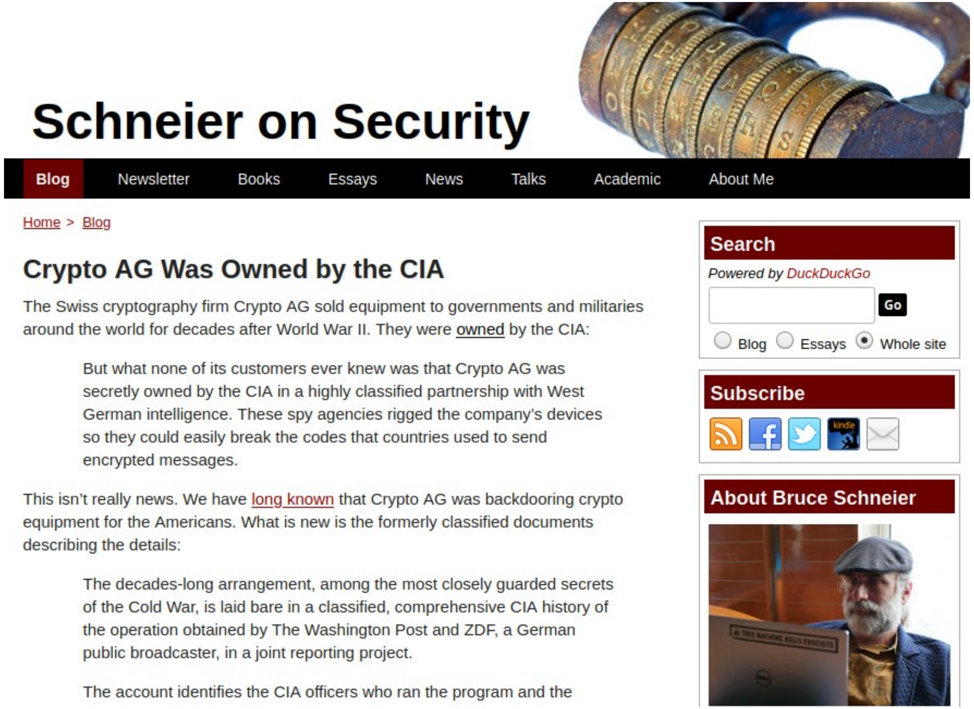
NIST finally dumps NSA-tainted random number algorithm

Summary: *Many years since a backdoor was discovered, probably planted by the NSA, public pressure finally forces NIST to formally remove Dual_EC_DRBG from their recommendations.*

By Larry Seltzer for Zero Day | April 23, 2014 -- 14:04 GMT (07:04 PDT)

Follow @lseltzer

Supply chain fail



Schneier on Security

Home > Blog

Crypto AG Was Owned by the CIA

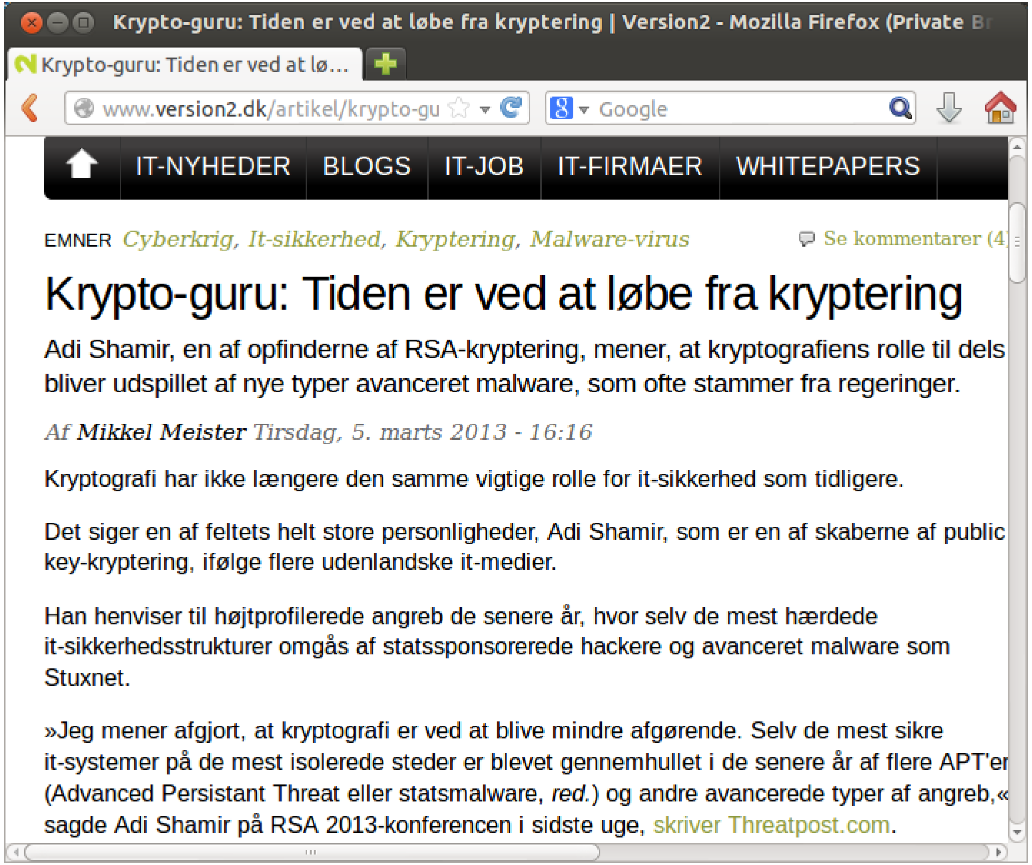
The Swiss cryptography firm Crypto AG sold equipment to governments and militaries around the world for decades after World War II. They were owned by the CIA:

> But what none of its customers ever knew was that Crypto AG was secretly owned by the CIA in a highly classified partnership with West German intelligence. These spy agencies rigged the company's devices so they could easily break the codes that countries used to send encrypted messages.

This isn't really news. We have long known that Crypto AG was backdooring crypto equipment for the Americans. What is new is the formerly classified documents describing the details:

> The decades-long arrangement, among the most closely guarded secrets of the Cold War, is laid bare in a classified, comprehensive CIA history of the operation obtained by The Washington Post and ZDF, a German public broadcaster, in a joint reporting project.
>
> The account identifies the CIA officers who ran the program and the

Malware fail



Krypto-guru: Tiden er ved at løbe fra kryptering | Version2 - Mozilla Firefox (Private B
Krypto-guru: Tiden er ved at lø...
www.version2.dk/artikel/krypto-gu
Google
IT-NYHEDER
BLOGS
IT-JOB
IT-FIRMAER
WHITEPAPERS

EMNER *Cyberkrig, It-sikkerhed, Kryptering, Malware-virus*

Se kommentarer (4

Krypto-guru: Tiden er ved at løbe fra kryptering

Adi Shamir, en af opfinderne af RSA-kryptering, mener, at kryptografiens rolle til dels bliver udspillet af nye typer avanceret malware, som ofte stammer fra regeringer.

*Af **Mikkel Meister** Tirsdag, 5. marts 2013 - 16:16*

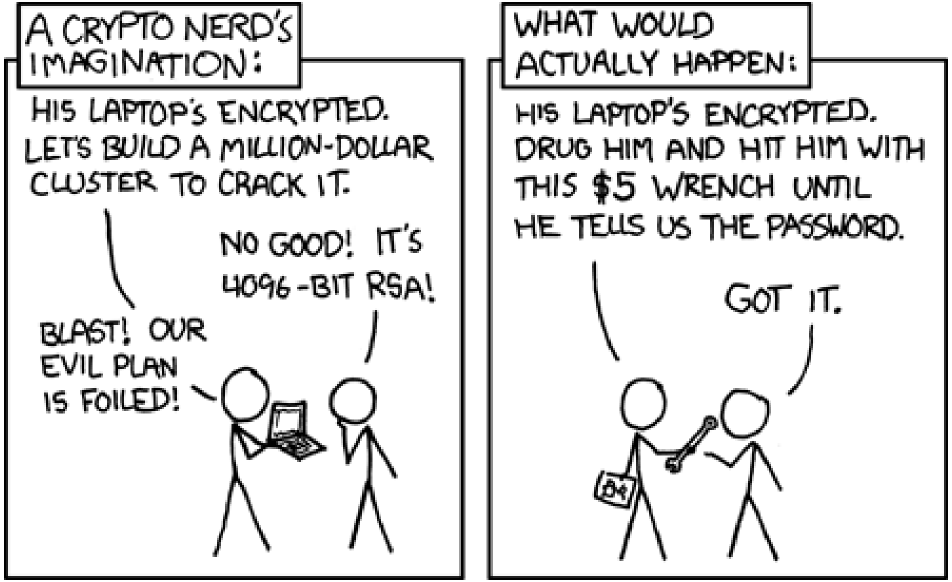
Kryptografi har ikke længere den samme vigtige rolle for it-sikkerhed som tidligere.

Det siger en af feltets helt store personligheder, Adi Shamir, som er en af skaberne af public key-kryptering, ifølge flere udenlandske it-medier.

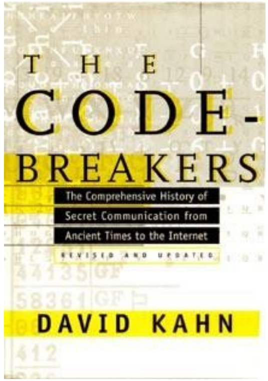
Han henviser til højtprofilerede angreb de senere år, hvor selv de mest hærdede it-sikkerhedsstrukturer omgås af statssponsorerede hackere og avanceret malware som Stuxnet.

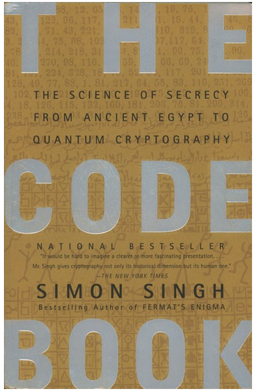
»Jeg mener afgjort, at kryptografi er ved at blive mindre afgørende. Selv de mest sikre it-systemer på de mest isolerede steder er blevet gennemhullet i de senere år af flere APT'er (Advanced Persistant Threat eller statsmalware, *red.*) og andre avancerede typer af angreb,« sagde Adi Shamir på RSA 2013-konferencen i sidste uge, skriver Threatpost.com.

Real-world fail


A CRYPTO NERD'S IMAGINATION:
HIS LAPTOP'S ENCRYPTED. LET'S BUILD A MILLION-DOLLAR CLUSTER TO CRACK IT.
NO GOOD! IT'S 4096-BIT RSA!
BLAST! OUR EVIL PLAN IS FOILED!
WHAT WOULD ACTUALLY HAPPEN:
HIS LAPTOP'S ENCRYPTED. DRUG HIM AND HIT HIM WITH THIS $5 WRENCH UNTIL HE TELLS US THE PASSWORD.
GOT IT.

Suggested reading


THE
CODE-BREAKERS
The Comprehensive History of Secret Communication from Ancient Times to the Internet
REVISED AND UPDATED
DAVID KAHN


THE
THE SCIENCE OF SECRECY FROM ANCIENT EGYPT TO QUANTUM CRYPTOGRAPHY
CODE
NATIONAL BESTSELLER
"It would be hard to imagine a clearer or more fascinating presentation. . . . Mr. Singh gives cryptography not only its historical dimension but its human one."
—THE NEW YORK TIMES
SIMON SINGH
Bestselling Author of FERMAT'S ENIGMA
BOOK