threatpost

TOTAL RECALL: TROY HUNT BREAKS DOWN HIS NISSAN HACK

by **Tom Spring** February 26, 2016 , 9:45 am

Last month, when researcher Troy Hunt argued the dangers of insecure APIs at a security workshop, little did he know hours later he would discover an API vulnerability that allowed remote access to onboard computers of 200,000 Nissan Leaf and eNV200 electric automobiles.

"After talking about the way applications can sometimes get APIs wrong, a workshop attendee goes back to his hotel room and 15 minutes later calls to say he has found something fishy with the Nissan Leaf smartphone app," Hunt said in an interview with Threatpost, speaking about the discovery.

The vulnerability, it turned out, allowed anyone with the right Nissan Leaf and eNV200 vehicle identification number (VIN) to remotely access the car's climate controls, battery status and GPS logs that included the dates, times and distances the car traveled.

Related Posts

Nissan Car Hack Allowed Remote Access
February 25, 2016 , 3:07 pm

Hunt said, Leaf owners were trying to figure out how to manipulate their vehicles because the app was unreliable and cumbersome. "A number of frustrated app users figured out all they needed to do was feed a URL into a browser to turn on their car's heat," Hunt said.

When Hunt originally took his findings to Nissan, he said they were all ears. Then, after the initial private disclosure, Hunt said, Nissan gave him the cold shoulder and still didn't fix the problem. Weeks later, when Hunt pointed out customers were slowly figuring out the vulnerability on their own, he told Nissan he was going to post his research on his website.

"Nissan was not considering this situation urgent," Hunt said. "I finally told Nissan I was publishing my findings before the vulnerability became more widely known and abused." It was only then, on Wednesday, that Nissan shut down the app that was creating the problem.

symmetric *cryptography*

cs642

computer security

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Announcement

* Midterm next week: Monday, March 7 (in-class)

* Midterm Review session Friday: March 4 (here, normal class time)

today

* Provable security
* Vernam's one-time-pad
* Shannon's security definition
* Block ciphers (AES)
* Block cipher modes of operation

review

flavors

* Symmetric cryptography
  - All parties have access to a **shared random string** K, called the key
  - Short keys
    - AES: 128b, 192b, 256b
  - Fast
  - Good for long messages

* Asymmetric cryptography
  - Each party creates a pair of keys: a public key pk and a secret key sk
  - Long keys
    - RSA: 2048b, 4096b, 8192b
  - Slow
  - Good for short messages

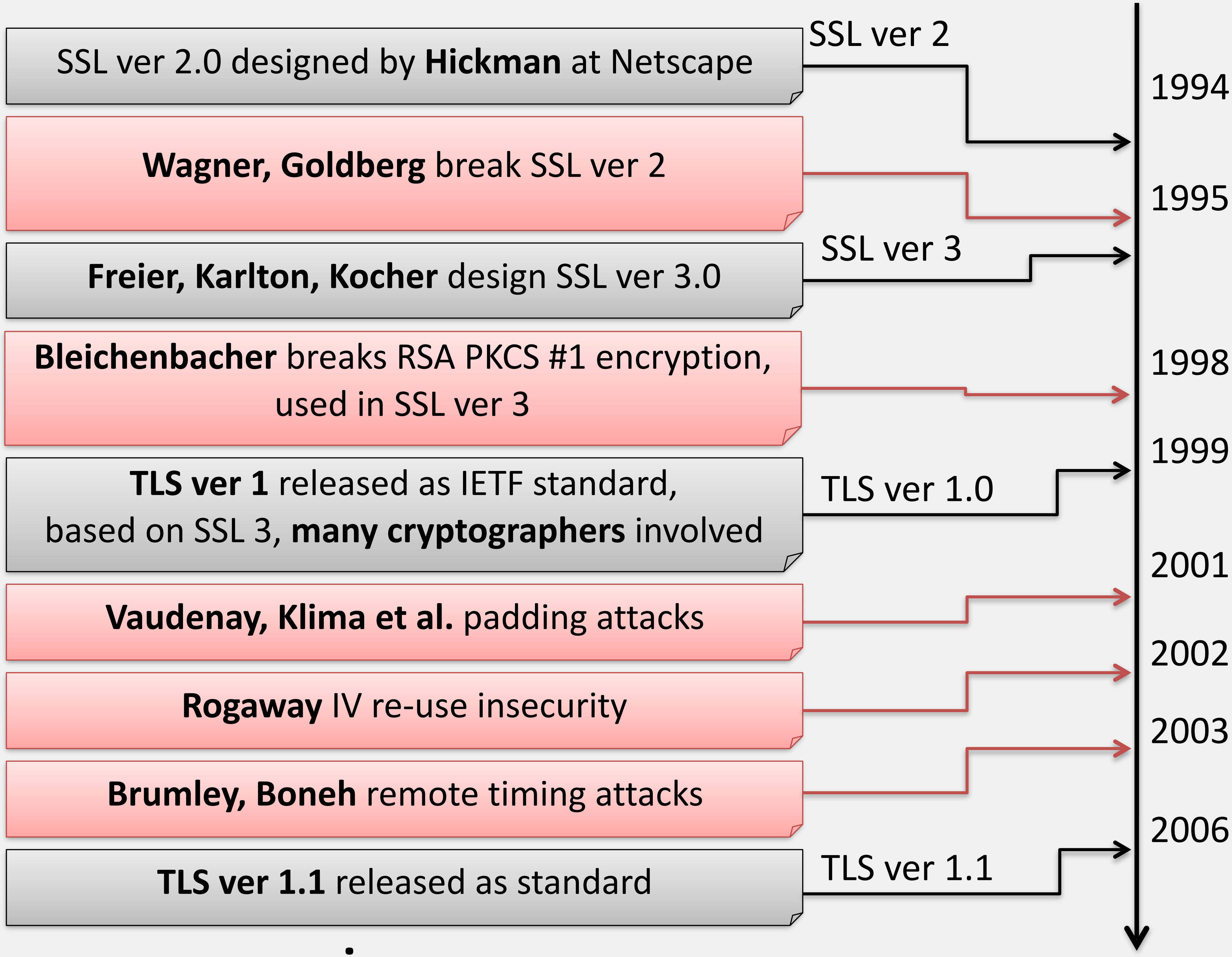
primitives

* Encryption
  / confidentiality
  / symmetric + asymmetric versions

* Message authentication codes
  / integrity, authentication
  / symmetric

* Digital signatures
  / integrity, authentication
  / asymmetric

* Key exchange



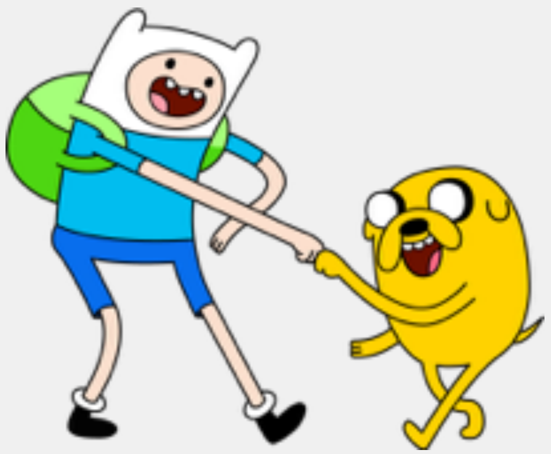
ancient history

iteration

* TLS was built via "design-break-redesign-break" iteration
* Some amount iteration is fundamental
* Designing secure protocols is **really hard**
  * the problems are rarely in the primitives
* Many other tools have similar stories:
  * SSH, IPsec, kerberos, WEP + WPA (WiFi), GSM (cell phone)

provable security

* Provable security supplements "design-break-redesign-break" iteration with a mathematical approach



1. Design a cryptographic scheme
2. Provide a proof of it's security

[Shannon, 1946]

Formal definitions

- Scheme semantics and assumptions
- Security

Security Proofs

- Security of a scheme cannot be broken if assumptions hold

enigma

* Put yourself in Shannon's place in 1946

* Enigma is state of the art cryptography developed by the Germans

* Broken by the Allies

* There must be a better way…

otp

* Vernam's one-time pad (1917)
* Fix message length L
* Kg: output random bit string K of length L

$$E(K,M) = M \oplus K = C \qquad D(K,C) = C \oplus K = M$$

security notion

Dfn. A symmetric encryption is *perfectly secret* if for all messages M,M' and ciphertexts C

$$\Pr[\, E(K,M)=C \,] \;=\; \Pr[\, E(K,M') = C \,]$$

where probabilities are over choice of K.

* Shannon's "perfect secrecy" notion, 1946
* Each message is equally likely to map to a given ciphertext
* Also: seeing a ciphertext leaks nothing about what message was encrypted

otp proof

Dfn. A symmetric encryption is *perfectly secret* if for all messages M,M' and ciphertexts C

$$\Pr[\, E(K,M)=C \,] \;=\; \Pr[\, E(K,M') = C \,]$$

where probabilities are over choice of K.

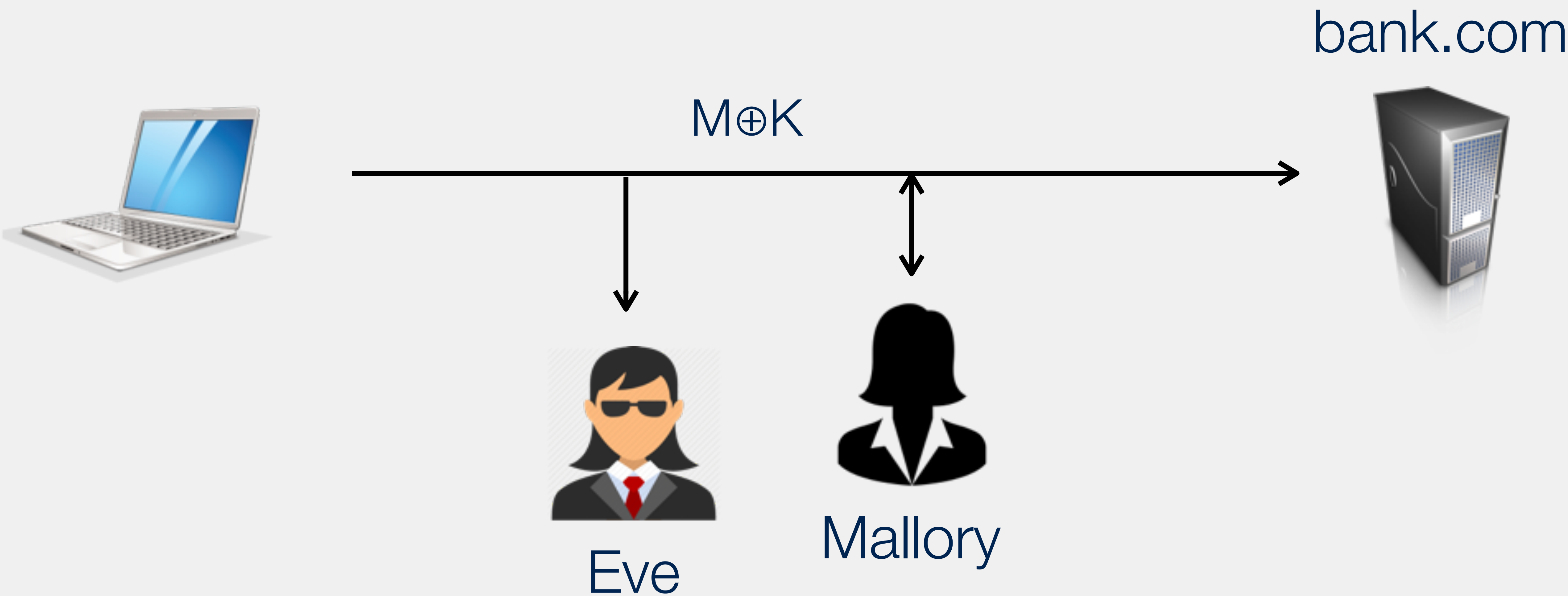
* Thm. OTP is perfectly secret.

* For any C,M of length L:

$$\Pr[\, E(K,M)=C \,] = 1/2^L$$

$$\Pr[\, E(K,M')=C \,] = 1/2^L$$

$$\Pr[\, E(K,M)=C \,] = \Pr[\, E(K,M')]$$



K must be as large as M

Reusing K for M,M' leaks M⊕M'

Message length is obvious

Mallory can make undetected modifications

Mallory can submit random messages

=> will decrypt to something

problems

provable security

* Cryptography as a ***computational science***
* Use computational intractability as basis for confidence

1. Design a cryptographic scheme
2. Provide a proof that no attacker with bounded computational resources can break it

[Goldwasser, Micali, Blum, 1980s]

Formal definitions

- Scheme semantics and assumption
- Security

Security Proofs (reductions)

Breaking scheme

$\Downarrow$

Breaking assumptions

provable security

* Provable security yields
  / well-defined assumptions and security goals
  / designers (and attackers) can focus on assumptions

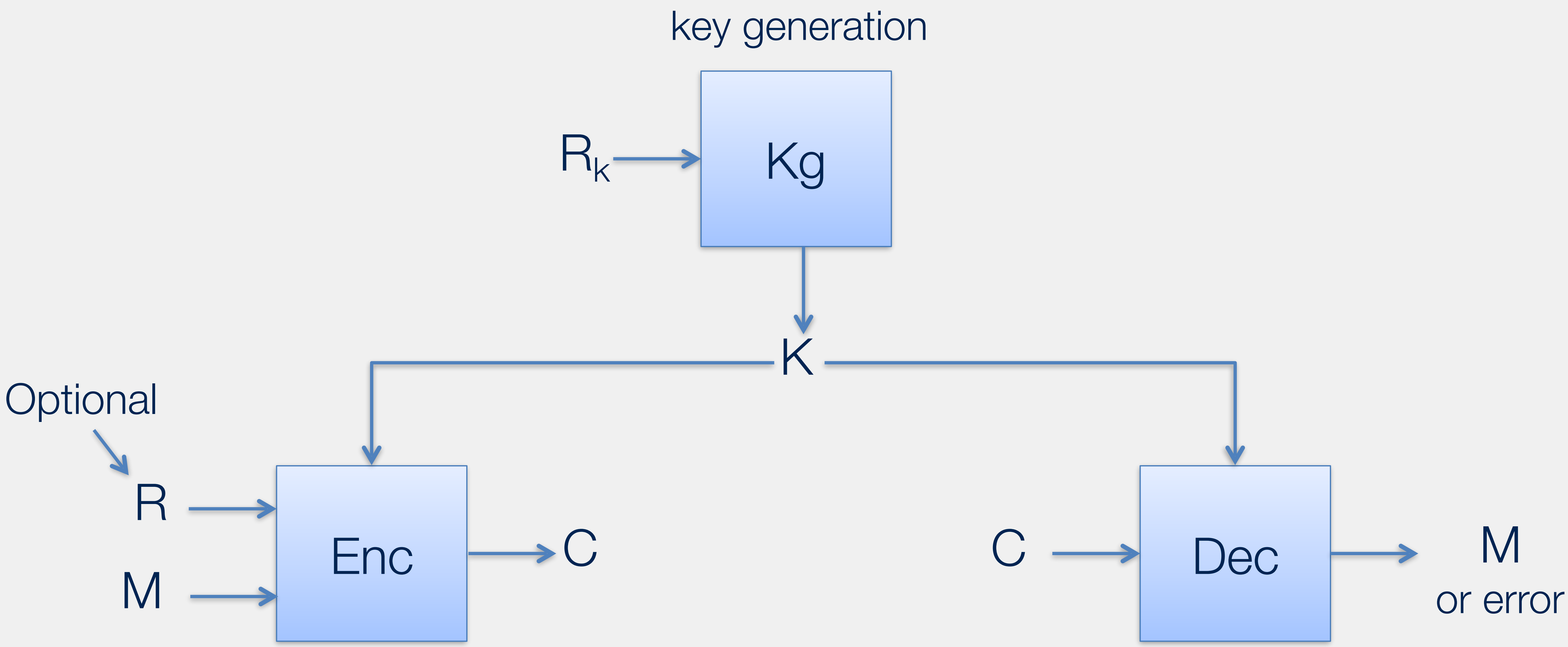
* As long as assumptions hold, we can be confident in security of a cryptographic scheme

typical assumptions

- Underlying primitives are hard to break
  - Factoring of large composite numbers is intractable
  - RSA permutation is hard to invert
  - Block ciphers (AES) are good pseudorandom permutations (PRPs)
  - Hash functions are collision resistant

- Confidence in primitives is gained by cryptanalysis, public design competitions
  - design-break-redesign-break over the years

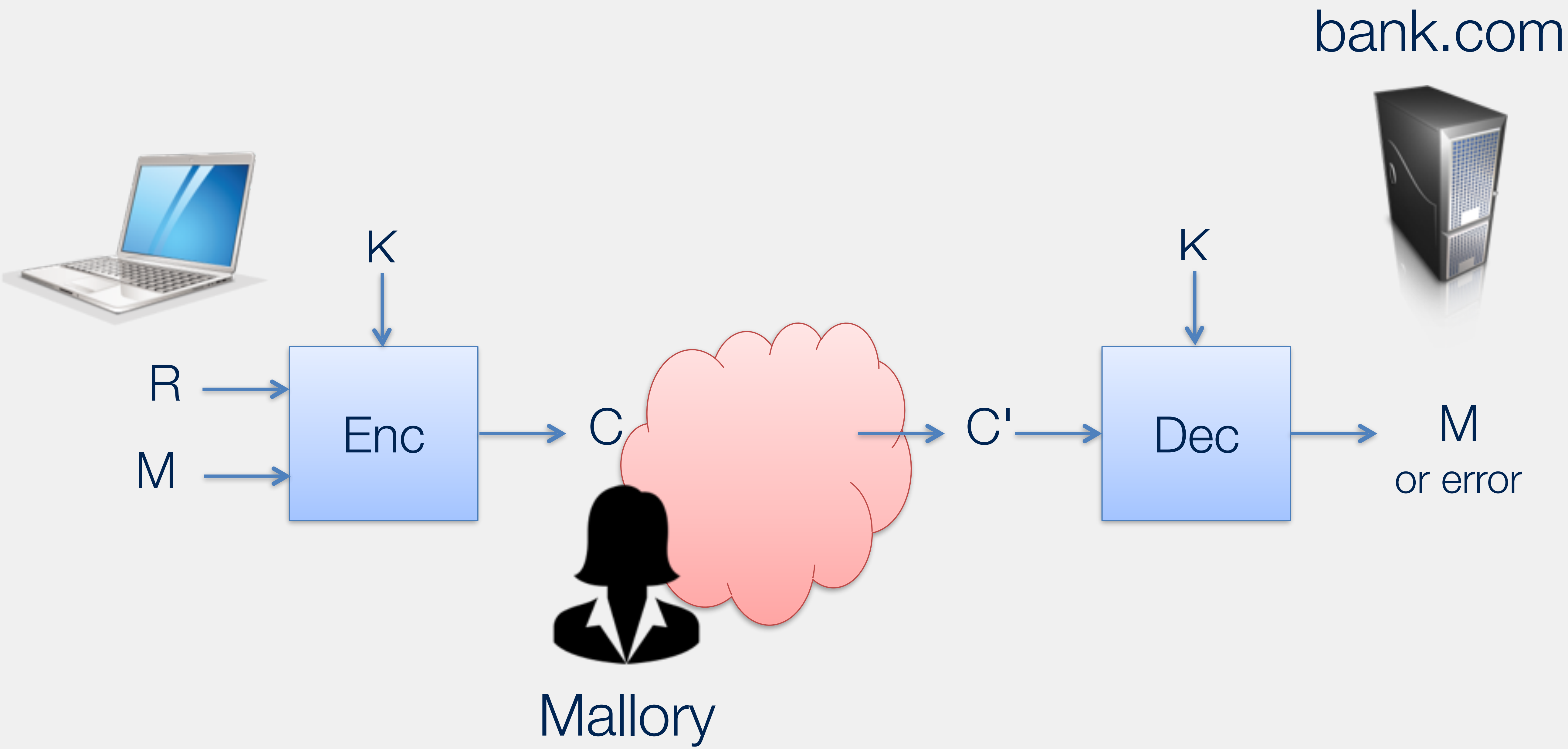
symmetric cryptography



Correctness: Dec(K, E(K,M,R)) = M

with probability 1 over all randomness

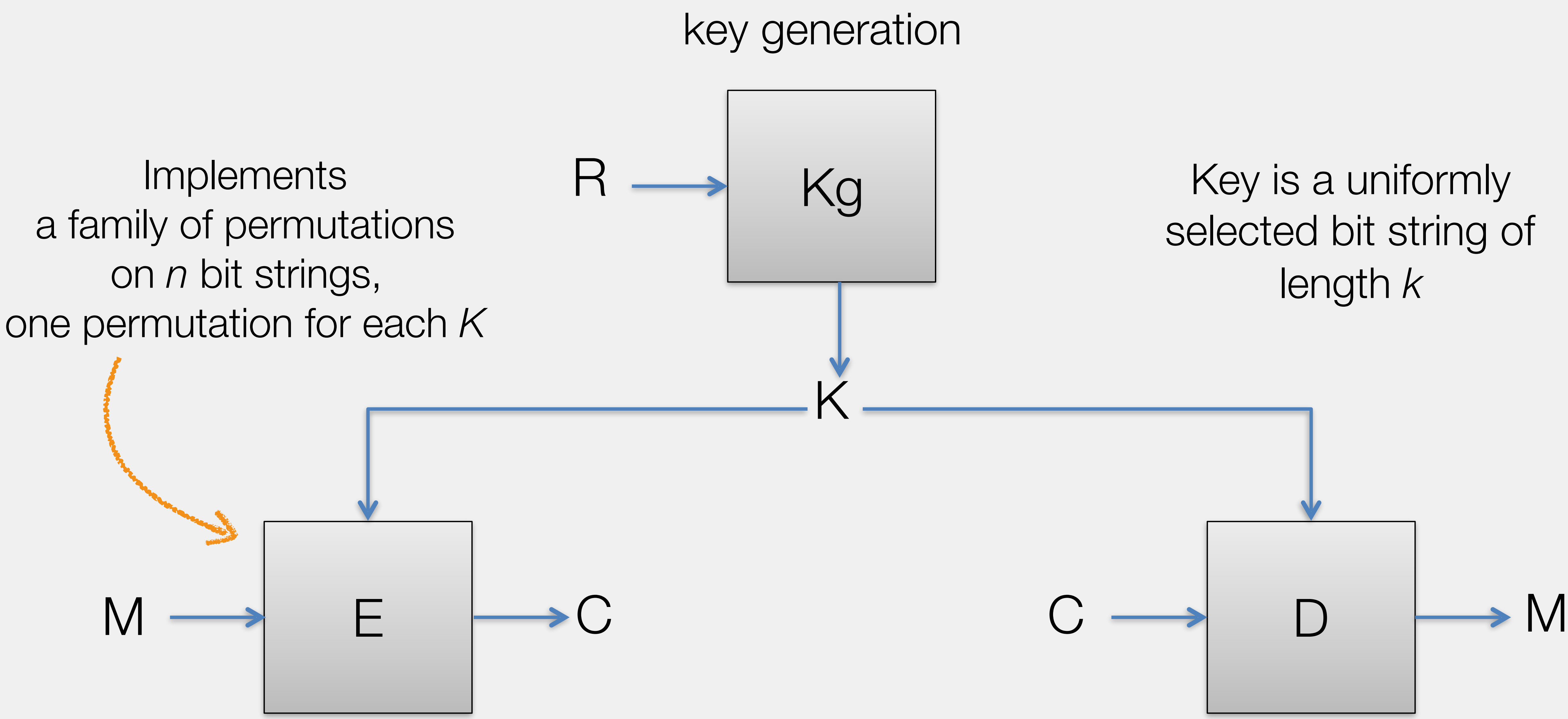
symmetric encryption scheme



What security goals do we need from symmetric encryption?

1. Confidentiality (Mallory cannot read M)
2. Integrity (Mallory cannot later M)
3. Authenticity (Mallory cannot forge her own messages M)

goals

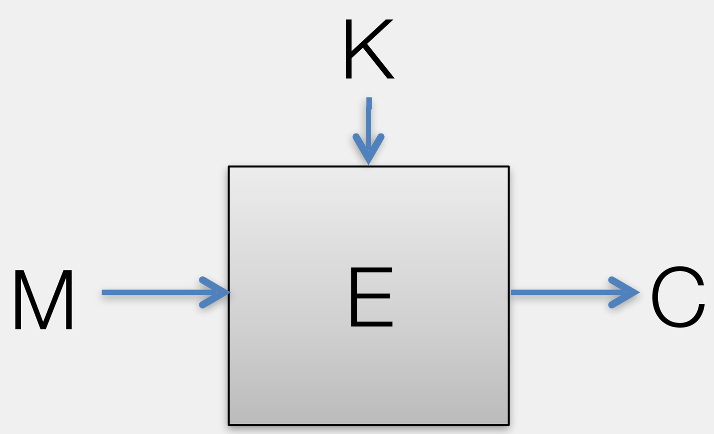


$$E: \{0,1\}^k \times \{0,1\}^n \rightarrow \{0,1\}^n$$

Security goal: $E(K,M)$ is indistinguishable from a random n-bit string for anyone that doesn't know K

block ciphers

$E: \{0,1\}^k \times \{0,1\}^n \rightarrow \{0,1\}^n$

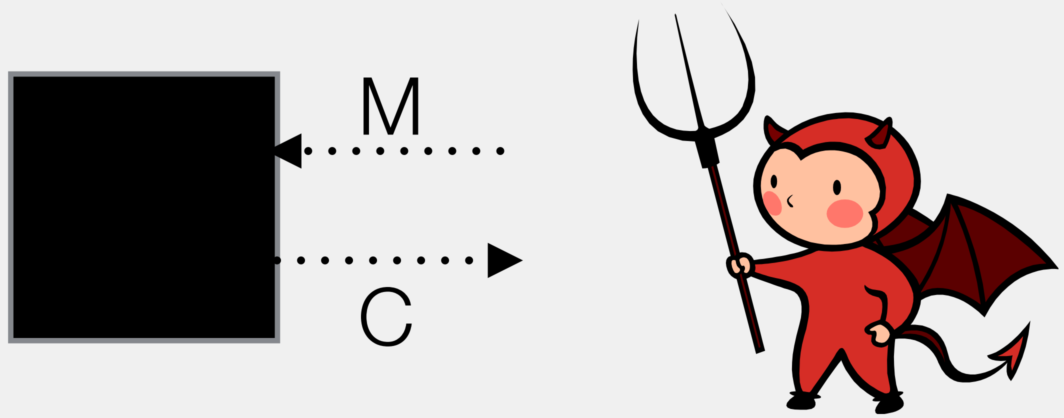


world 1

Let C be a string chosen uniformly at random

world 0

???



Can adversary distinguish between World 0 and World 1?

If this holds for all polynomial time adversaries, then *E* is called a secure pseudorandom function (PRF)

block cipher security

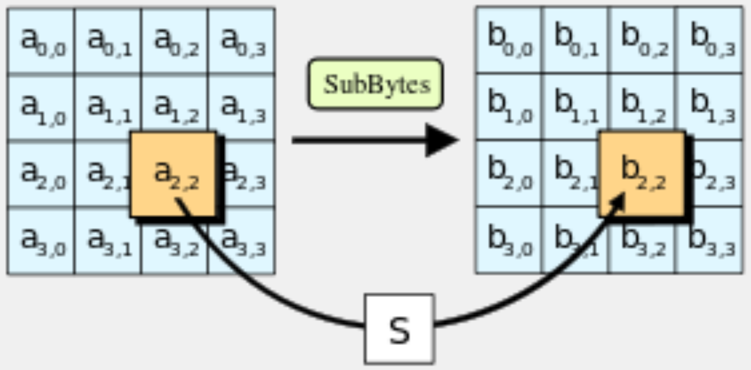
* Advanced Encryption Standard (AES)

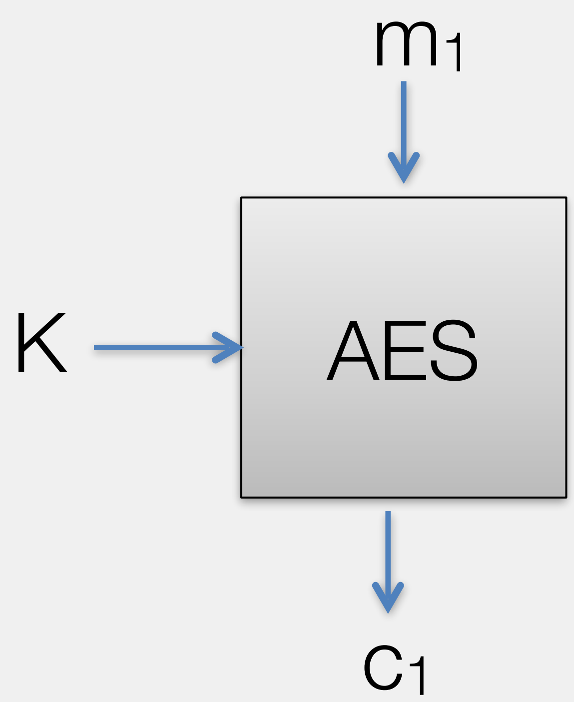
* Current standard for a secure block cipher

* Chosen by public competition, run by NIST, academic cryptographers

* Key sizes: 128b, 192b, 256b

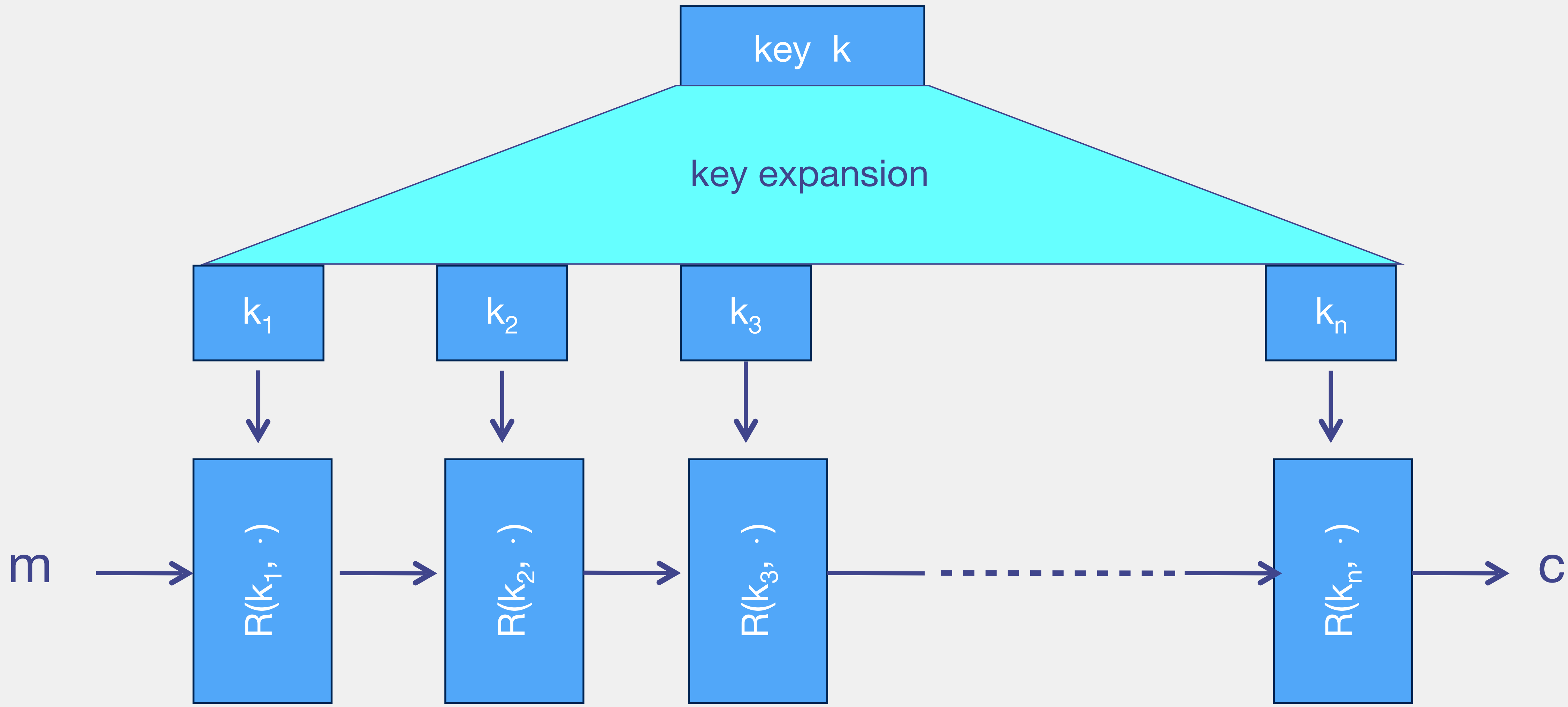
* Block size: 128b





aes

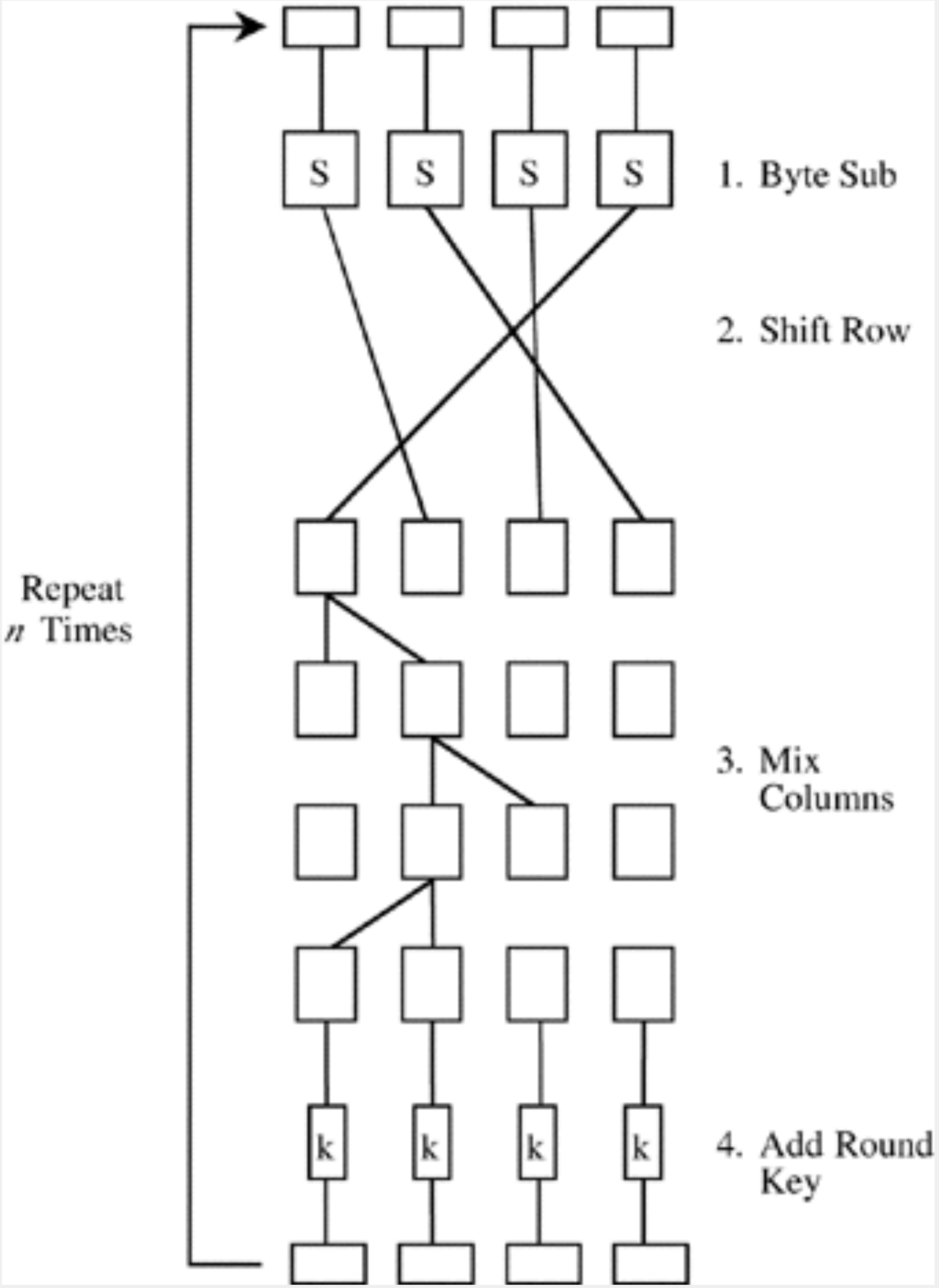
building a block cipher



R(k,m): round function

AES-128 n=10

[slide credit: Dan Boneh, CS155]



Designing good block ciphers is a dark art

Must resist subtle attacks: differential attack, linear attacks, others

Chosen through public design contests

Use build-*break*-build-*break* iteration

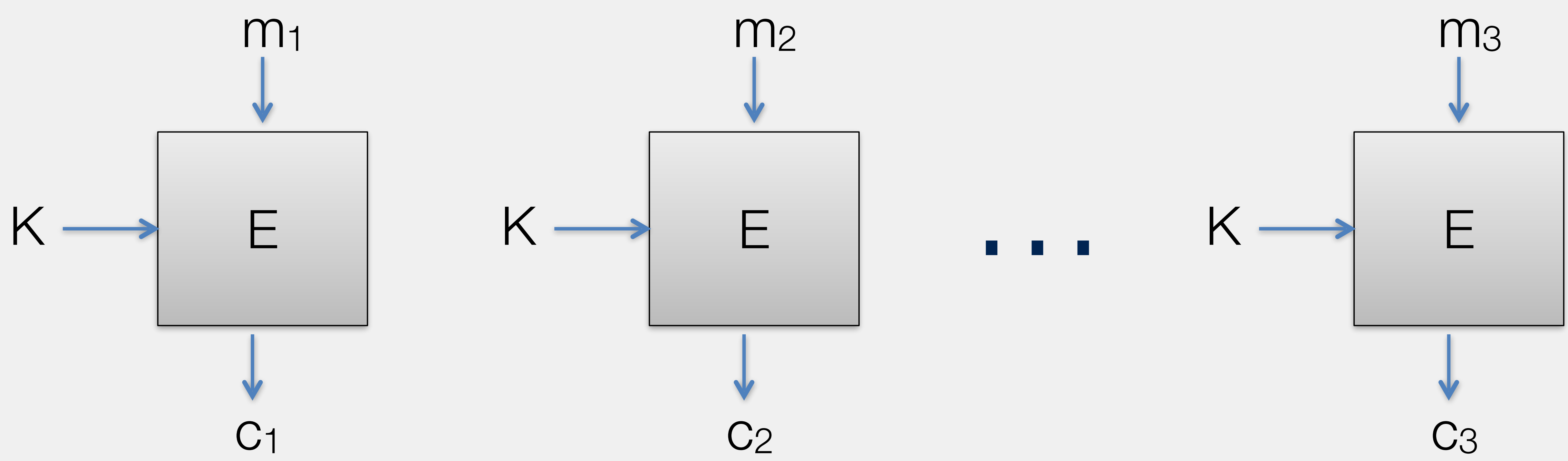
aes round function

Attack	Attack type	Complexity	Year
Bogdanov, Khovratovich, Rechberger	chosen ciphertext, recovers key	$2^{126.1}$ time + some data overheads	2011

- Brute force attack against AES: 2^{128}
- ~4x speedup

best attacks

$M = m_1\, m_2\, m_3\, m_4 \ldots m_L$



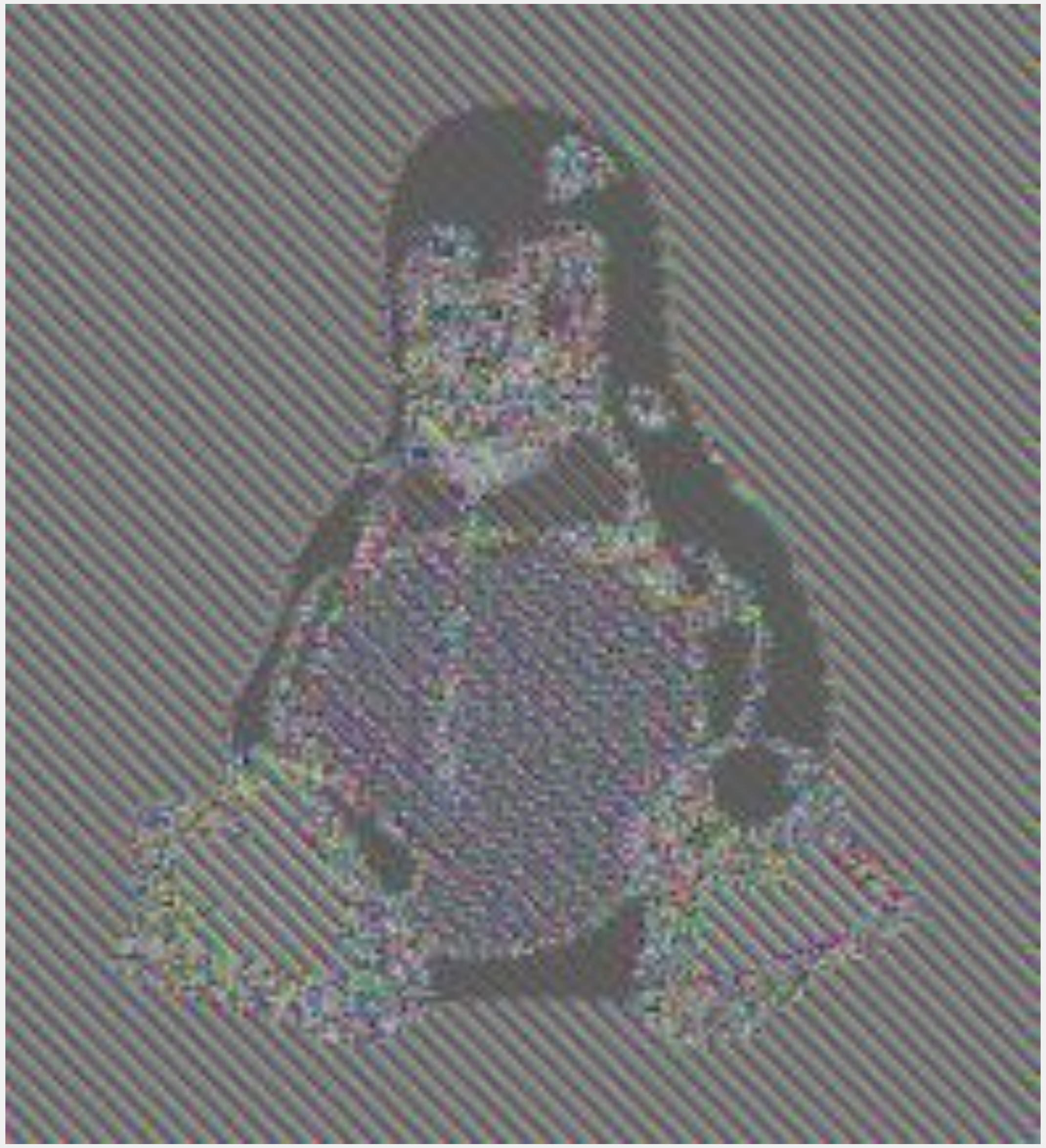
$C = c_1\, c_2\, c_3\, c_4 \ldots c_L$

Electronic Code Book (ECB) mode

modes of operation

[images from wikipedia]

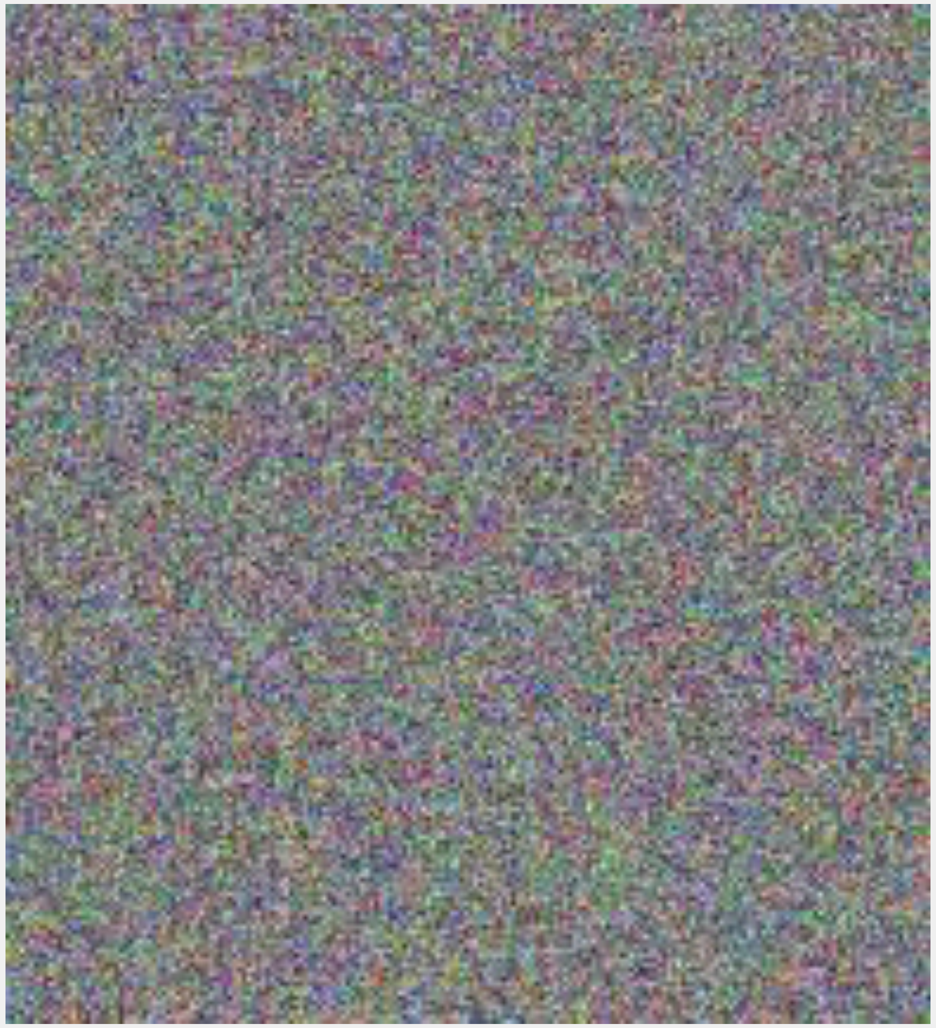
image encrypted with ECB



ECB is the *natural way* to implement encryption with block ciphers
But it's *insecure*
Basically → it's a complicated substitution cipher

If $m_i = m_j$ then $E(k, m_i) = E(k, m_j)$

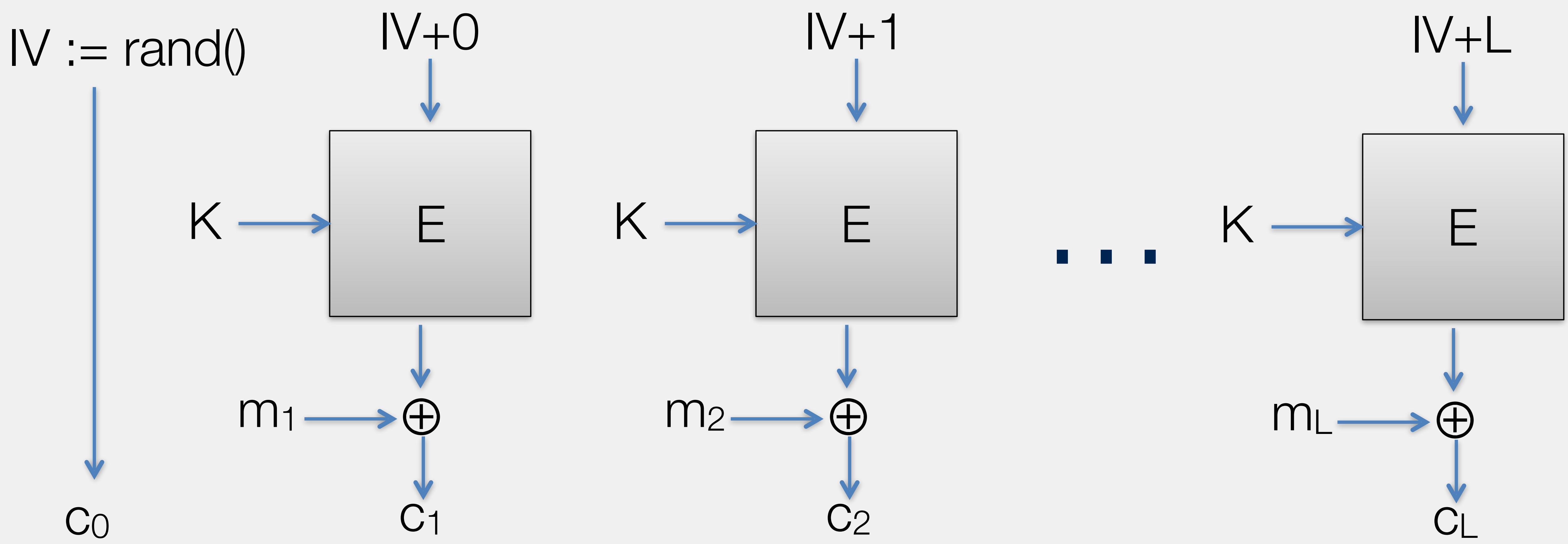
ecb



CTR, GCM, any
randomized mode

secure modes

$M = m_1\, m_2\, m_3\, m_4 \ldots m_L$



$C = c_0\, c_1\, c_2\, c_3\, c_4 \ldots c_L$

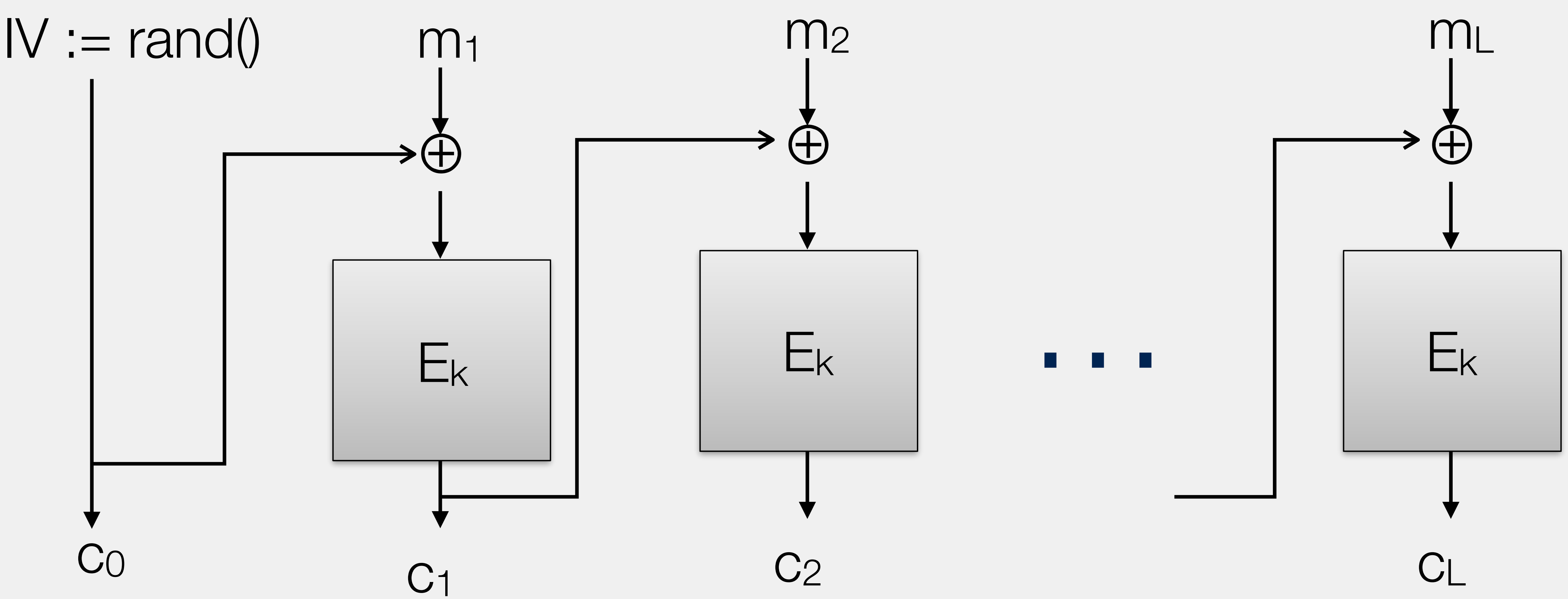
Counter (CTR) mode

How do we do decryption?

think-*pair*-share

ctr

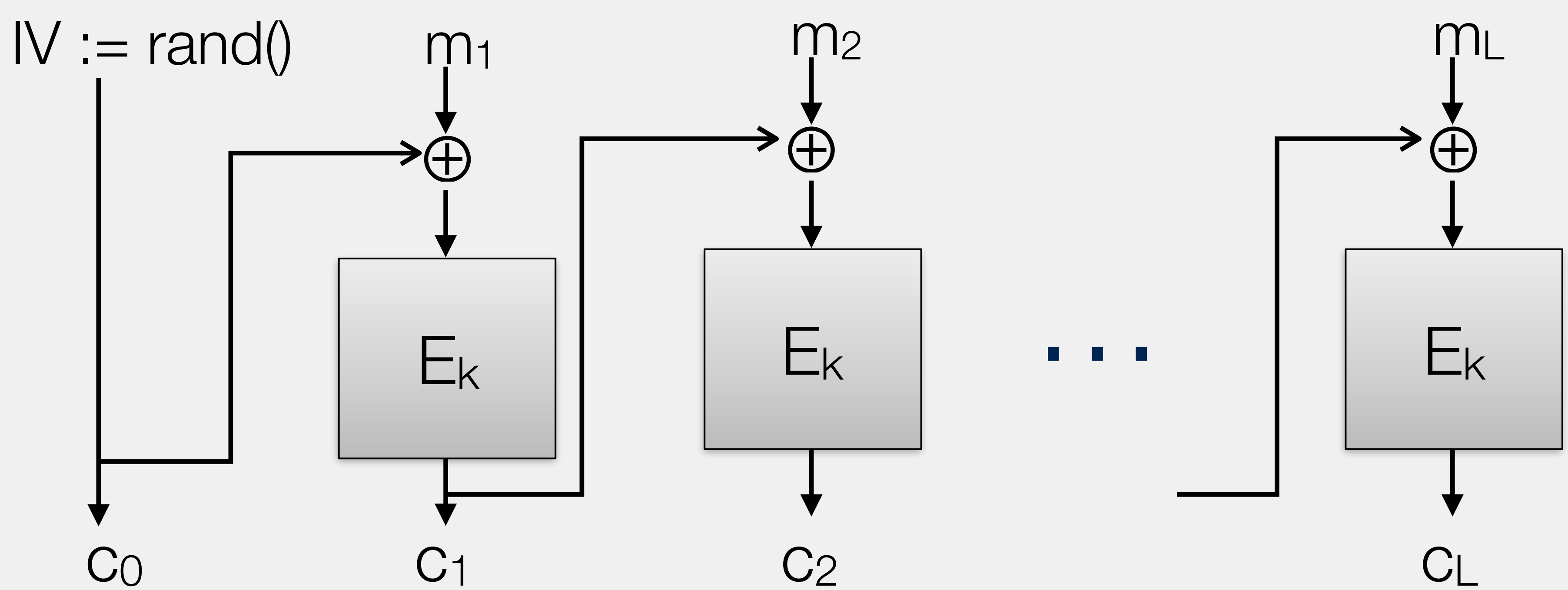
$M = m_1\, m_2\, m_3\, m_4 \ldots m_L$

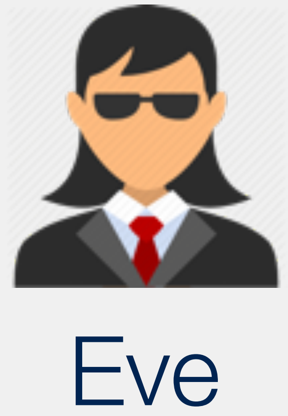


$C = c_0\, c_1\, c_2\, c_3\, c_4 \ldots c_L$

Cipher Block Chaining (CBC) mode

cbc





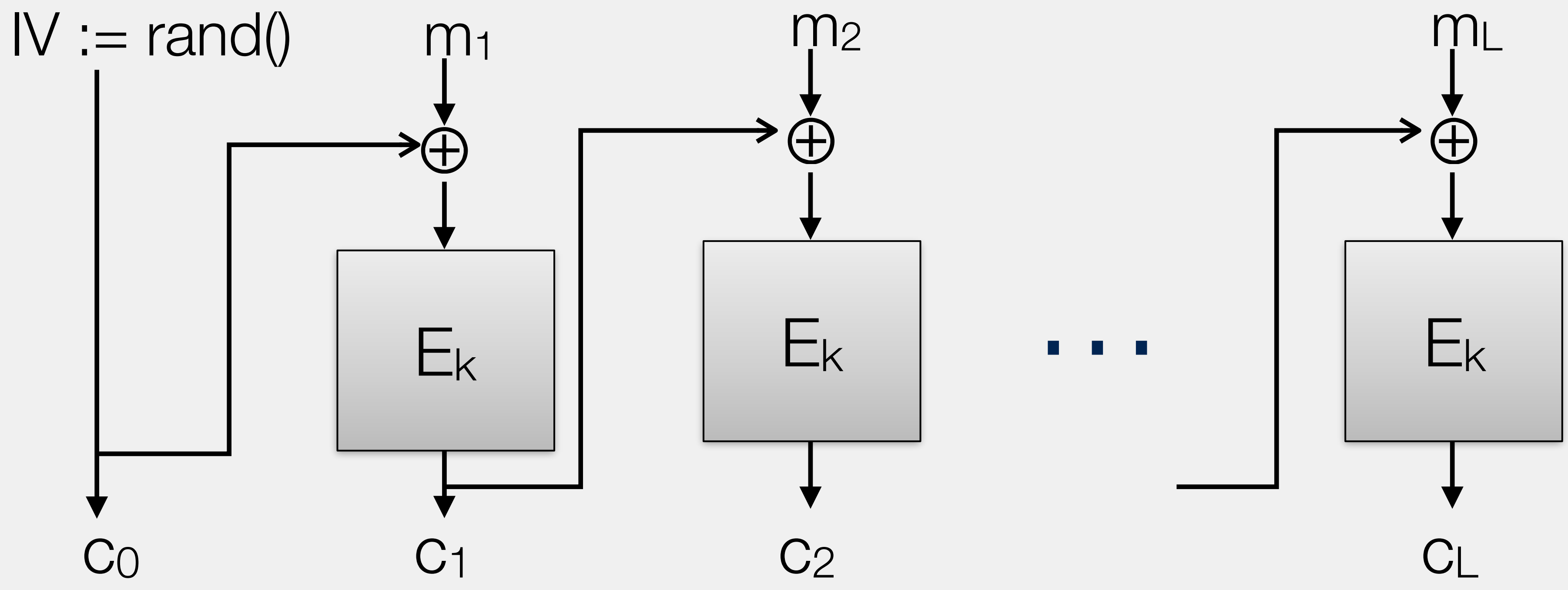
Can attacker learn K from just c_0,c_1,c_2?
Implies attacker can break E (recover block cipher key)

Can attacker m_1,m_2,m_3 from c_0,c_1,c_2?
Implies attacker can invert block cipher without K

Can attacker learn one of M from c_0,c_1,c_2?
Implies attacker can break PRF security of E

Provably: passive adversaries cannot learn anything about M if E is secure

passive security



Mallory

What about forging messages?

active security

* Provable security
* Vernam's one-time pad
  / Shannon's "perfect secrecy"
* Block ciphers (AES)
* Block cipher modes of operations
  / ECB - obvious, but insecure!!
  / CTR
* Exit slips
  / 1 thing you learned
  / 1 thing you didn't understand

recap