

Overview of post-quantum cryptography

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Cryptography = “secret writing”.

Achieve various security goals
by secretly transforming messages.

Major theme of research:

Users have cost constraints.

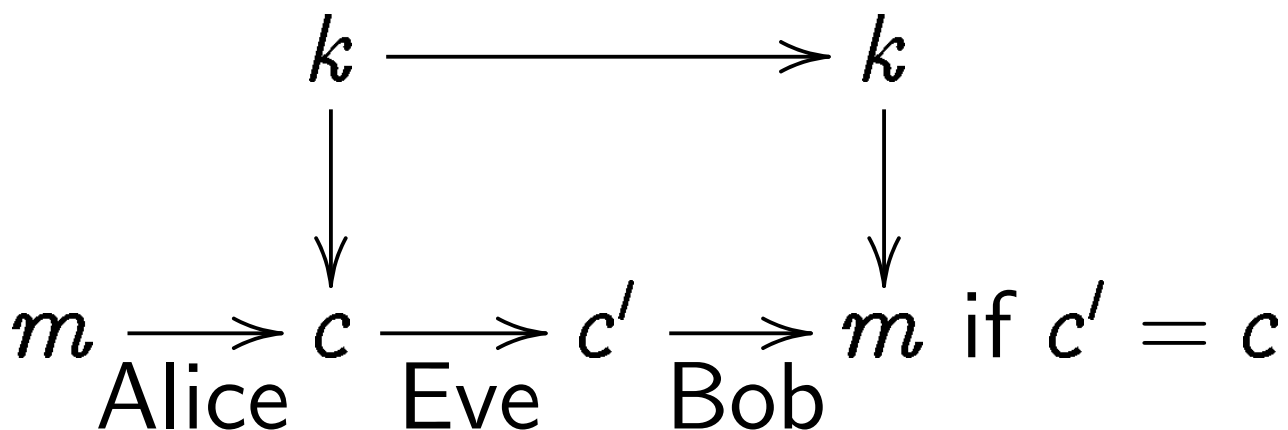
Can be challenging to reach
acceptable security levels.

Secret-key cryptography

Prerequisite: Alice and Bob share a short secret key k not known to eavesdropper Eve.

Security goals:

Confidentiality and integrity for any number of messages exchanged by Alice and Bob, despite Eve's espionage+forgery.



Public-key signatures

Prerequisite:

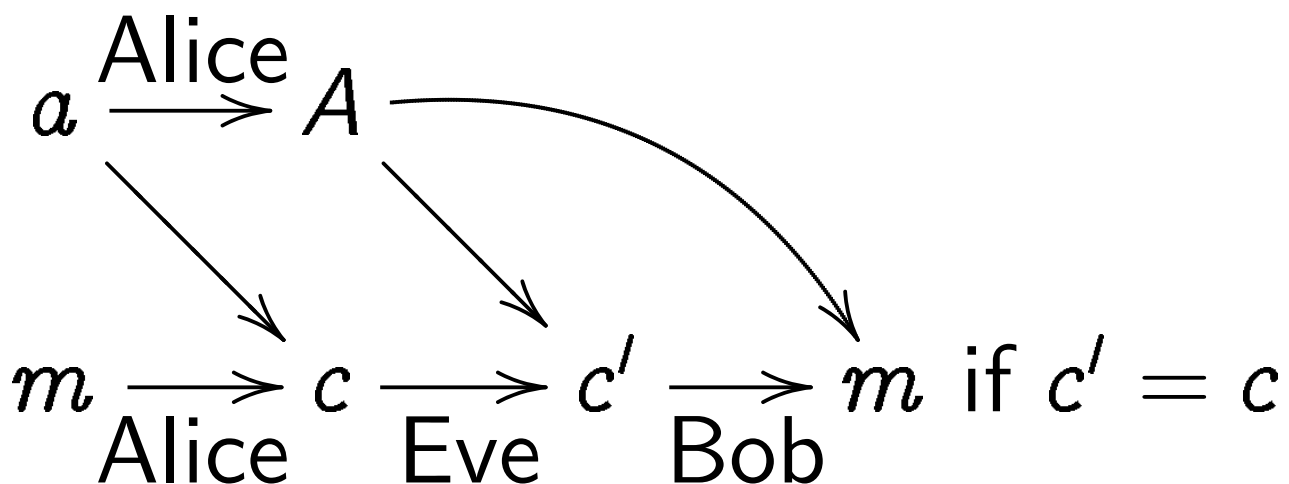
Alice has a short secret key a ,
corresponding public key A .

Everyone knows A .

Eve does not know a .

Security goal: Integrity

for any number of messages
published by Alice.



Public-key encryption (DH form)

Prerequisite:

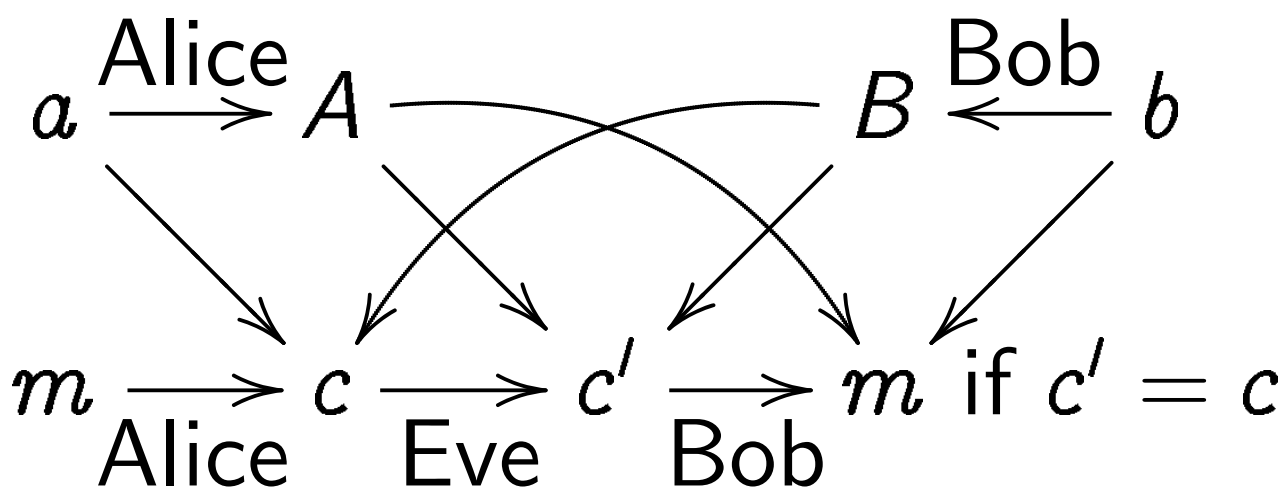
Alice has a , A ; Bob has b , B .

Public knows A and B .

Eve does not know a , b .

Security goals:

Confidentiality and integrity
for any number of messages
exchanged by Alice and Bob.



Advanced security goals

Many other security goals studied in cryptography:
stopping traffic analysis,
securely tallying votes,
searching encrypted data,
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But I'll focus on the most fundamental operations: secret-key cryptography, public-key signatures, public-key encryption.

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Critical for cryptography:
attackers exploit physical reality.

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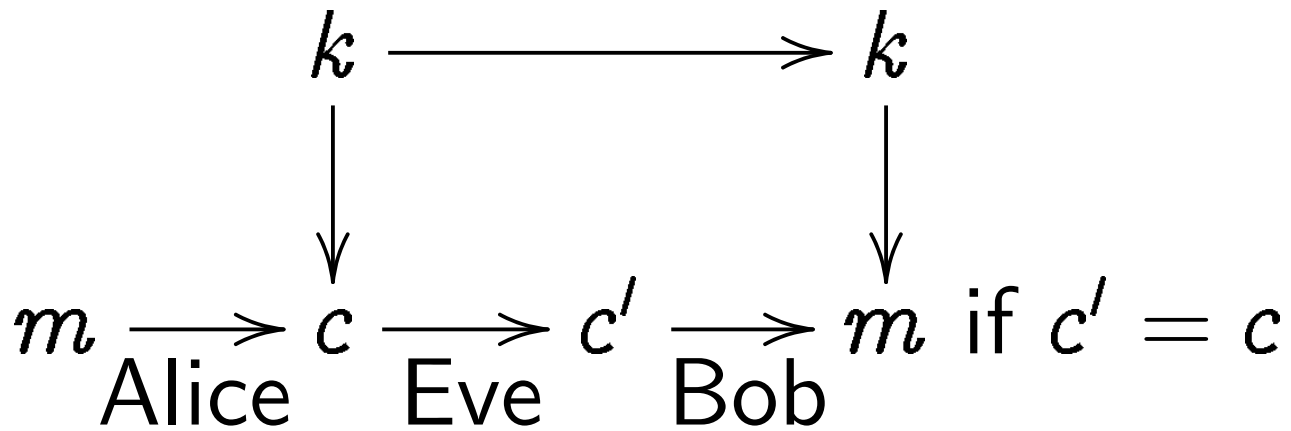
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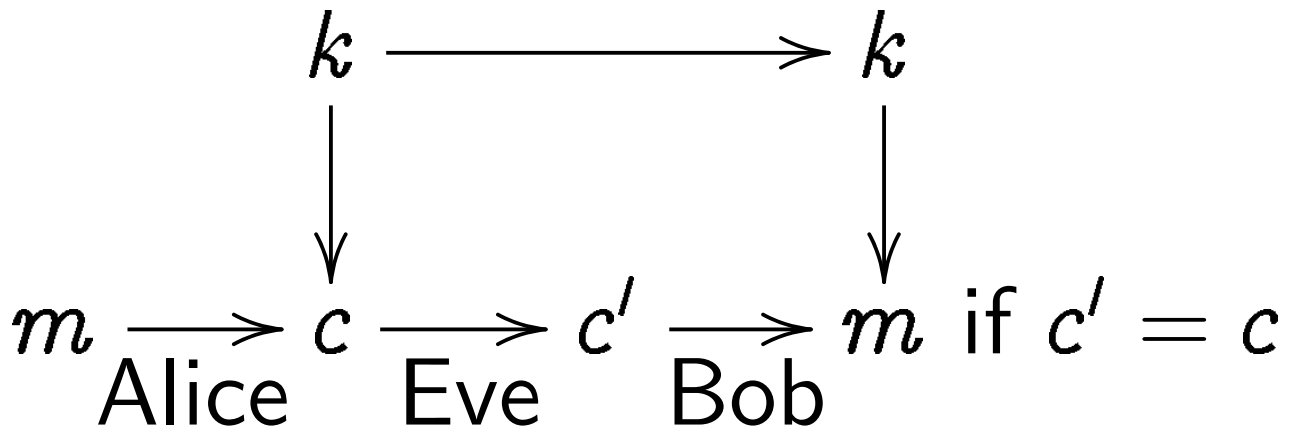
⇒ Hundreds of papers on
post-quantum cryptography.

Post-quantum secret-key crypto



Very easy solutions if k is
long uniform random string.

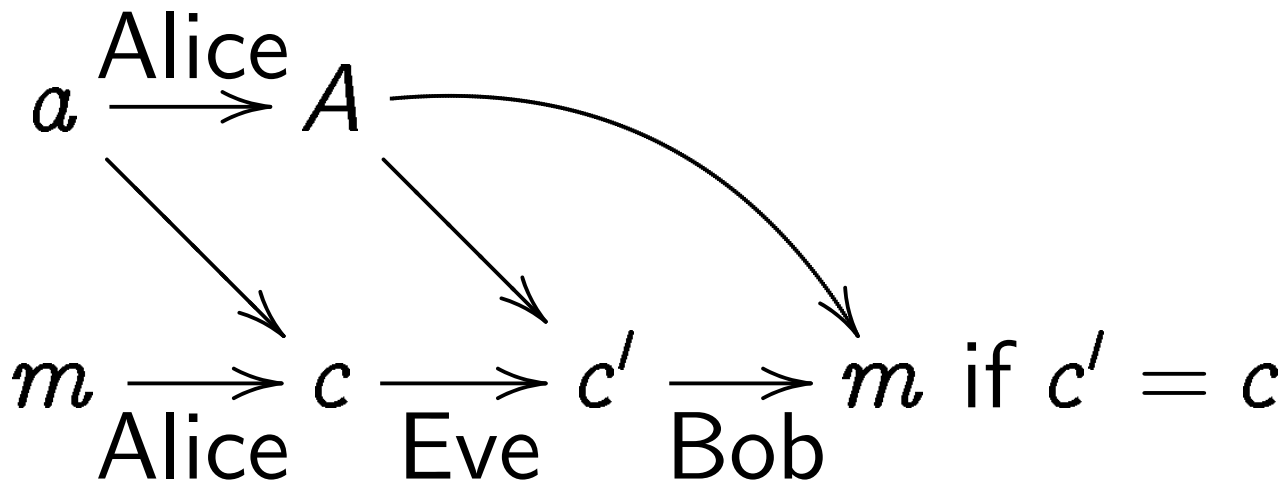
Post-quantum secret-key crypto



Very easy solutions if k is long uniform random string.

Already standardized method to expand short k into string indistinguishable from long k :
1998 Daemen–Rijmen “Rijndael” cipher (“AES”) using 256-bit key.
Security analyzed in papers by dozens of cryptanalysts.

Post-quantum public-key signatures

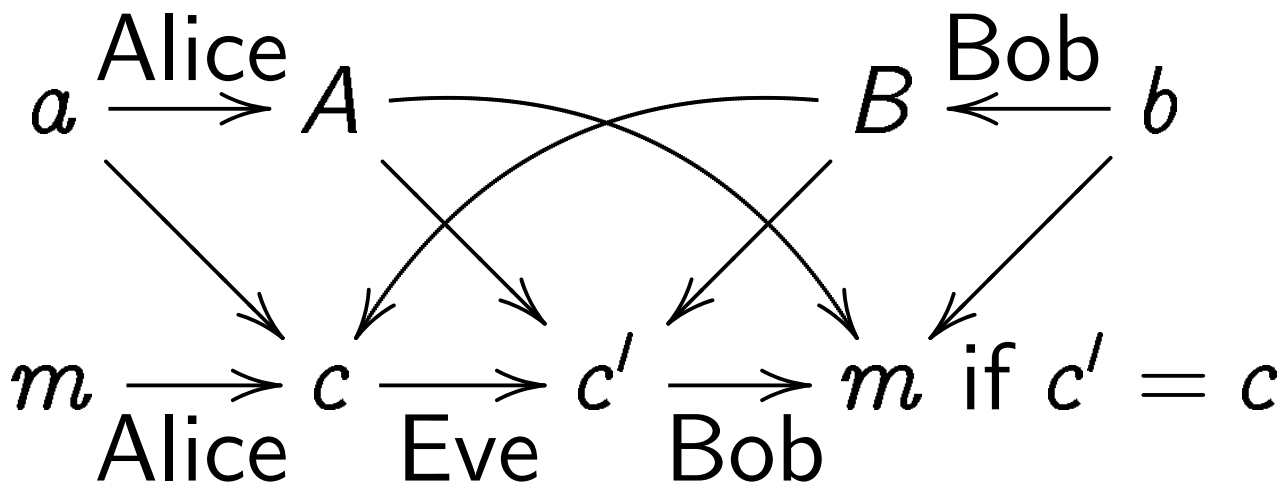


Safe, ready for standardization:
1979 Merkle hash-tree
public-key signature system.

Modern variants of system
are guaranteed to be as secure
as the underlying hash function.

Reasonable choice of function:
Keccak with 576-bit capacity.

Post-quantum public-key encryption



Safe, ready for standardization:
1978 McEliece encryption
using binary Goppa codes.

Main security-analysis papers:
1981, 1988, 1988, 1989, 1989,
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1998, 2008, 2009, 2009, 2009,
2010, 2011, 2011, 2012, 2013.

Examples of post-quantum research

Better secret-key crypto:

smaller, faster, easier to protect against side channels, etc.

Lattice-based cryptography:

similar idea to code-based;
maybe allows smaller keys;
security analysis not as mature.

Signatures using codes/lattices.

Multivariate quadratics:

very short signatures;
maybe tolerable for encryption.

<http://pqcrypto.org>