Wireless Systems Security

EE/NiS/TM-584-A/WS

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Week 4:
More Security Topics

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Evolution of Cryptography

- Monoalphabetic substitution, e.g.,
  - Caesar cipher {a,b,c,d,e,f,…,x,y,z} -> {b,c,d,e,f,g,…,y,z,a}
  - Atbash cipher {a,b,c,d,e,f,…x,y,z} -> (z,y,x,w,v,….c,b,a}
  - Any permutation of the alphabet
  - Easily solved by observing single and double letter frequencies
  - English (like most other non-ideograph languages) have distinct letter frequencies over a small alphabet.
  - Encoding English letters requires $\log_2(26) \sim 4.7$ bits/letter,
  - but information content in English text is

    $\Sigma\ p \log_2(p)$

    With unequal letter probabilities, actual information content is much lower.

    Equivocation of source is the effective information content

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    $$S\ p \log_2(p)$$

    With unequal letter probabilities, actual information content is much lower.
    Equivocation of source is the effective information content

- Polyalphabetic substitution:

  `thisisamessagetobeencrypted` - plaintext
  `badbadbadbadbadbadbadbadbad` - key stream
  `vimujwcniuteifxqcigogtztvfh` - ciphertext

  - Correlation-like techniques find the length of the key stream, k
  - Problem then reduces to solving k monoalphabetic ciphers
  - Using running text (e.g., from an agreed to book) makes solution harder, but with enough ciphertext, both the plaintext as well as the key stream are easily found

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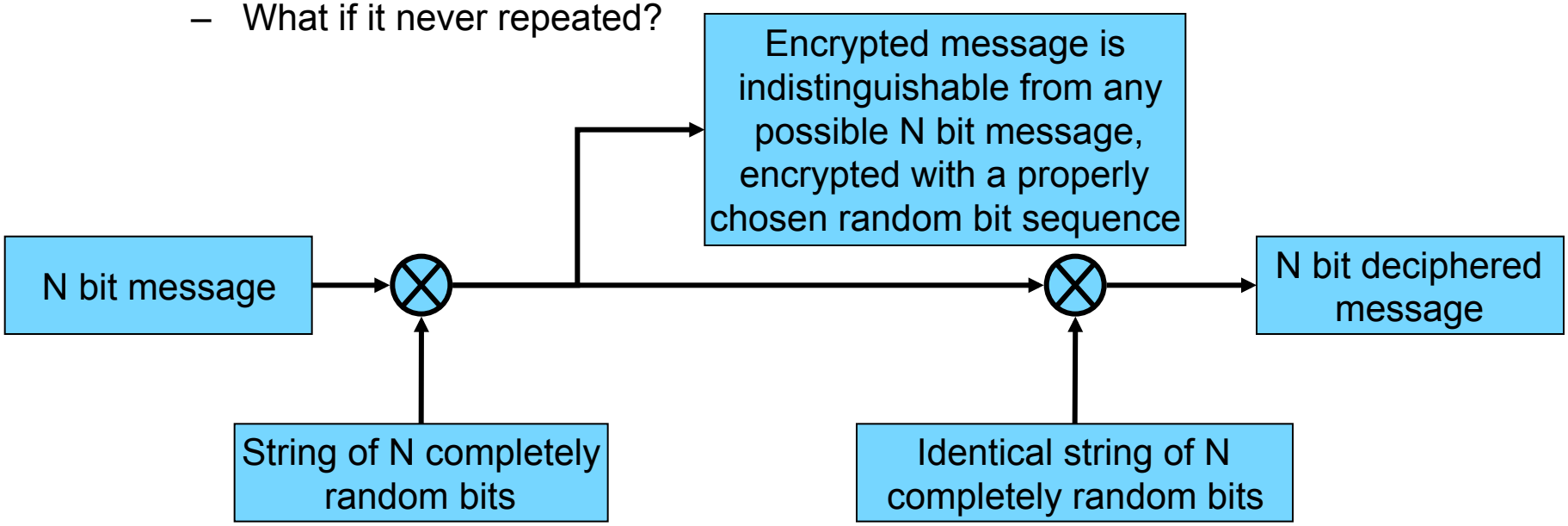
Evolution of Cryptography - 2

- Weakness of polyalphabetic cipher is repetition of the key stream
  - What if it never repeated?



- One-time-pad is the only provably secure cryptographic system

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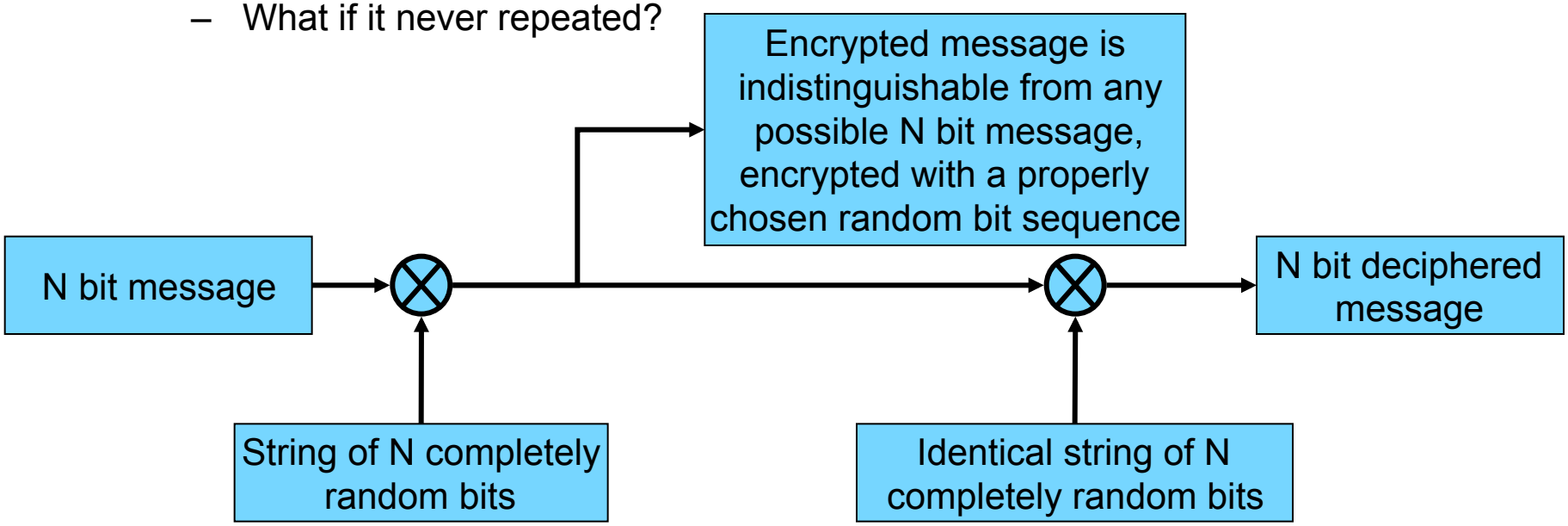

- One-time-pad is the only provably secure cryptographic system
  What happens if key sequence is (accidentally) reused?

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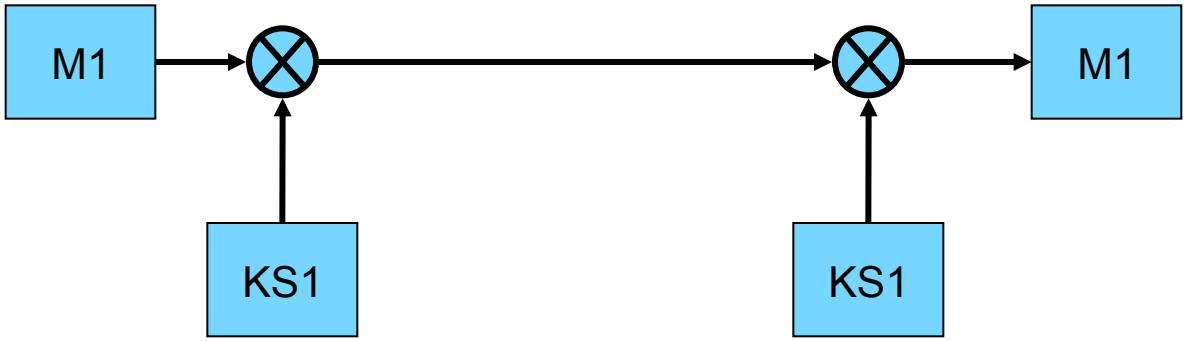
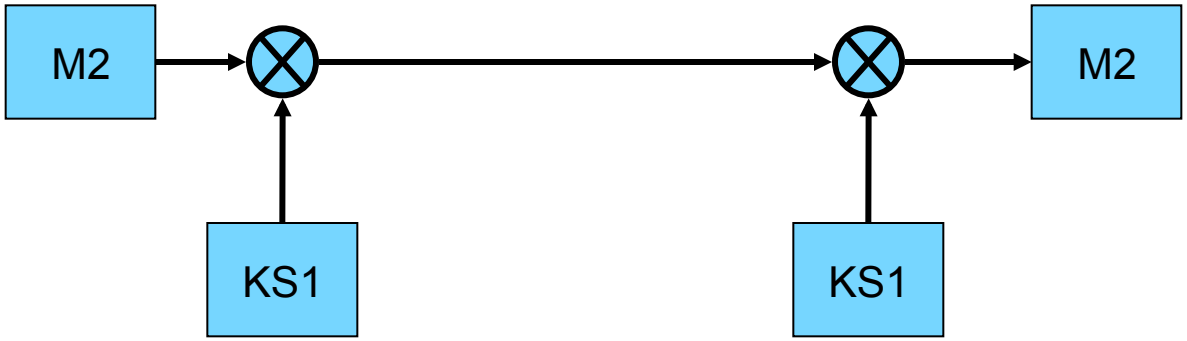
One-time pad Key Reuse



Sender (or receiver) accidentally sent M2, reusing KS1, previously used for M1



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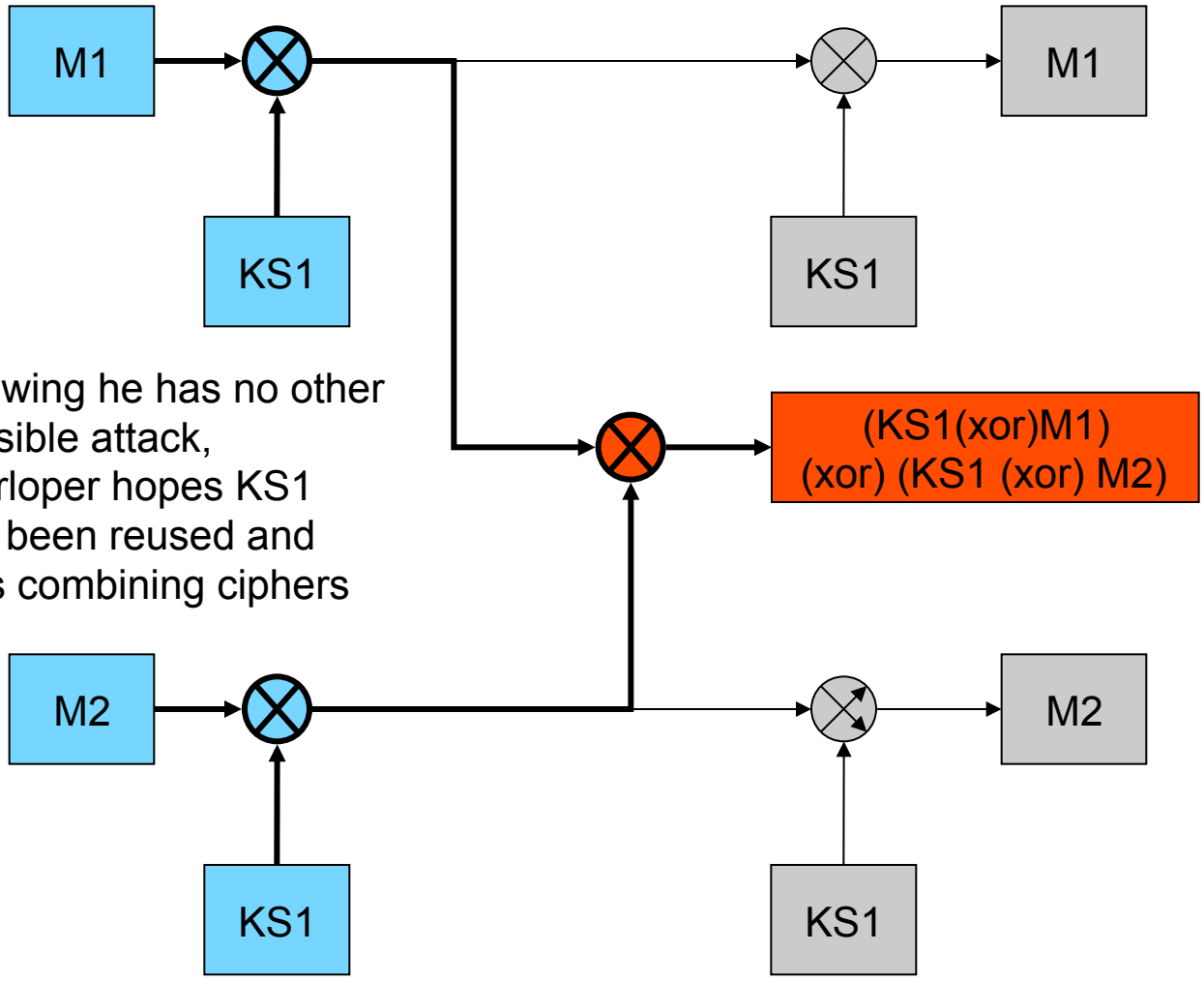
One-time pad Key Reuse



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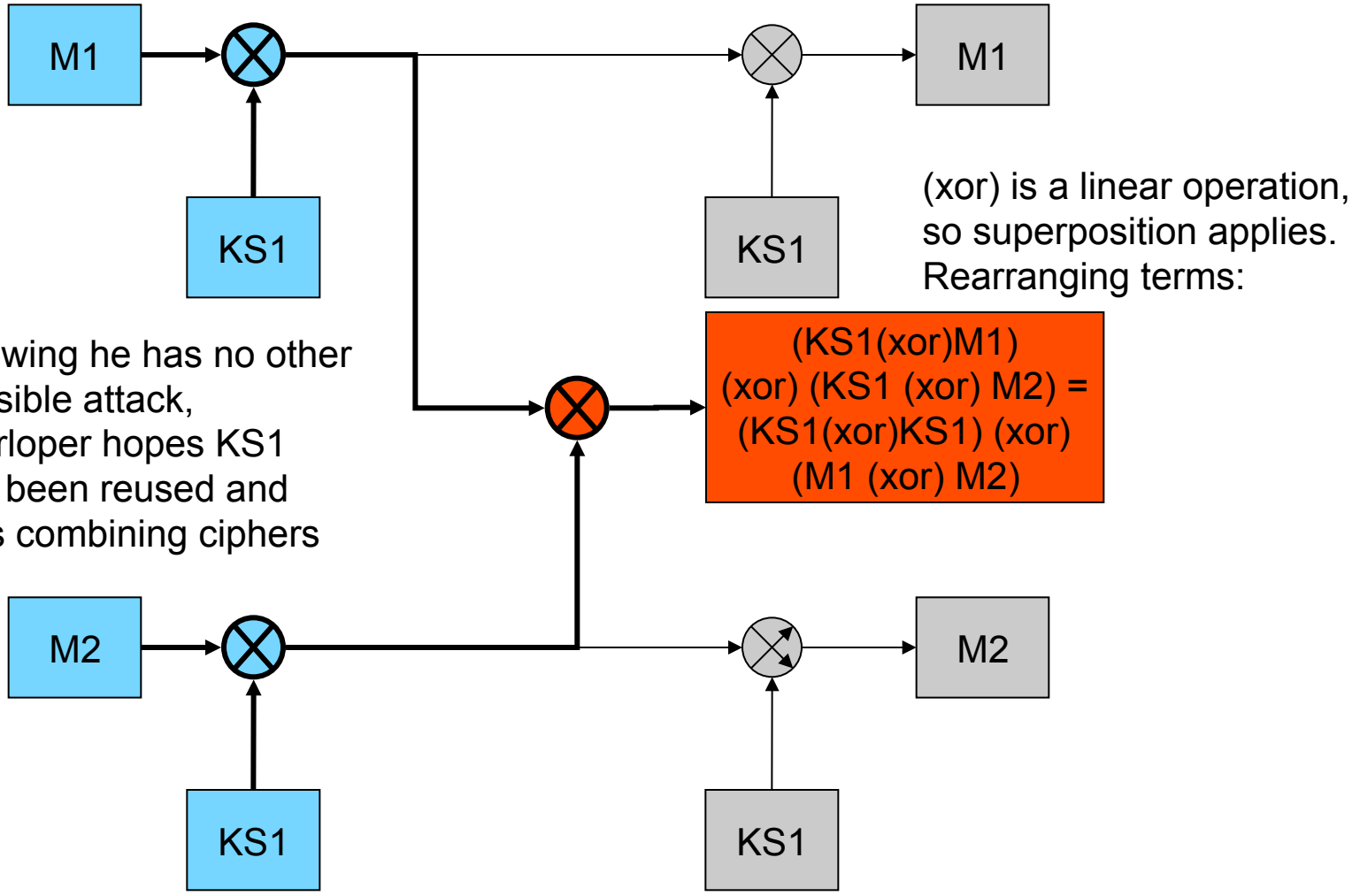

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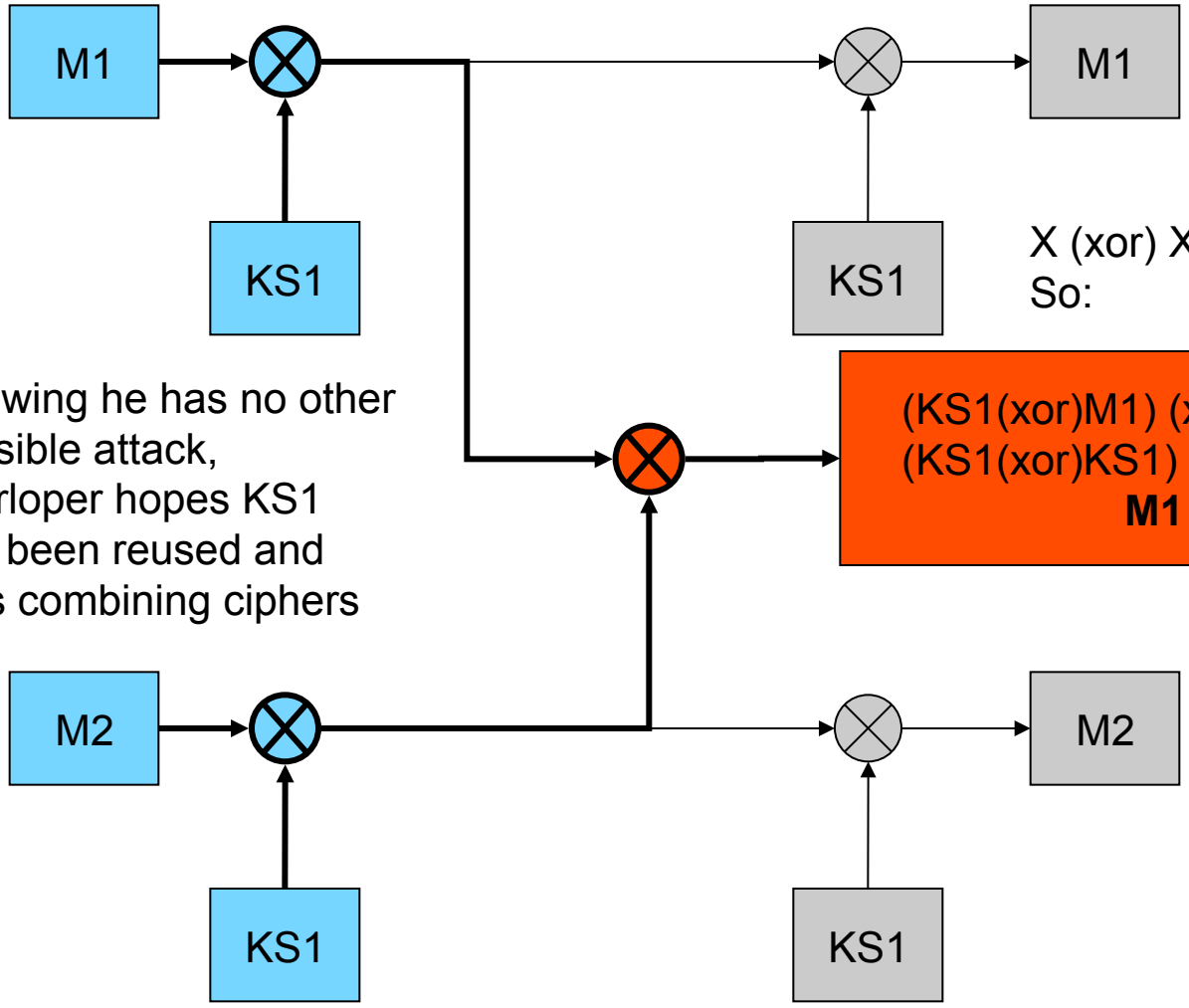

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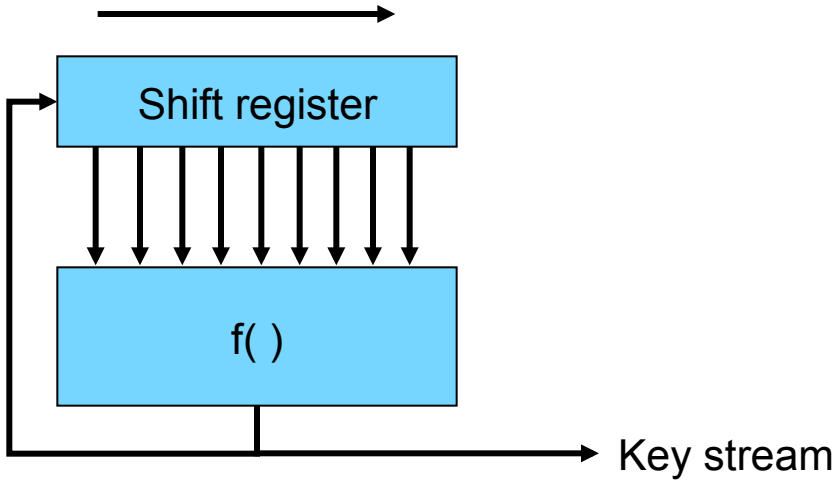
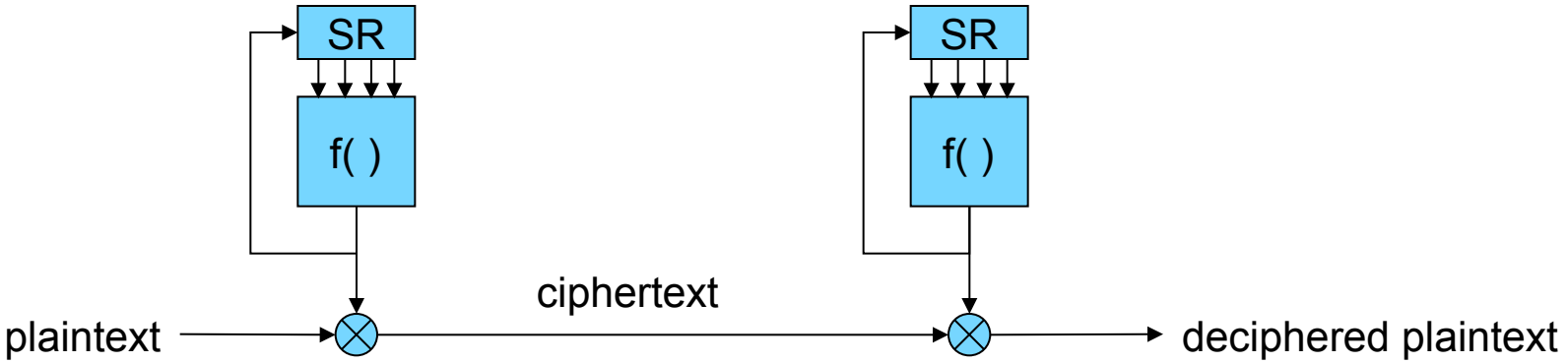
Generating Long Pseudo-Random Sequences

- For N bit register, if f(x) is linear, 2N-1 bits of key stream are sufficient to find f( )
- So, f( ) must be nonlinear





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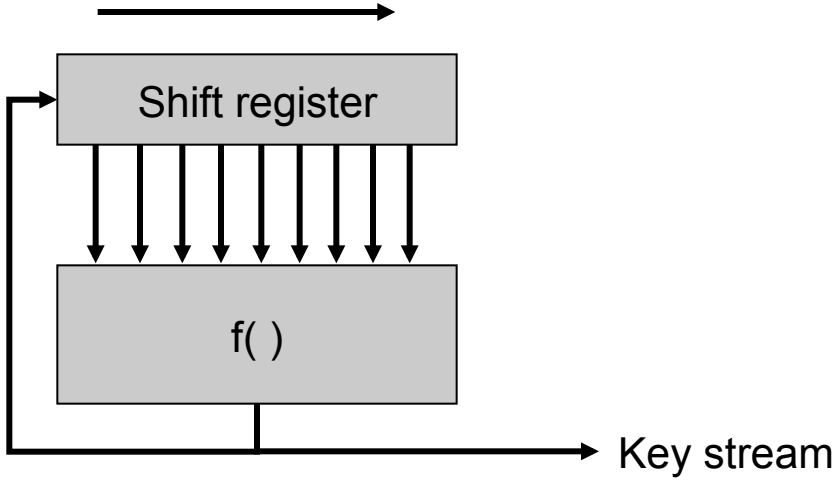
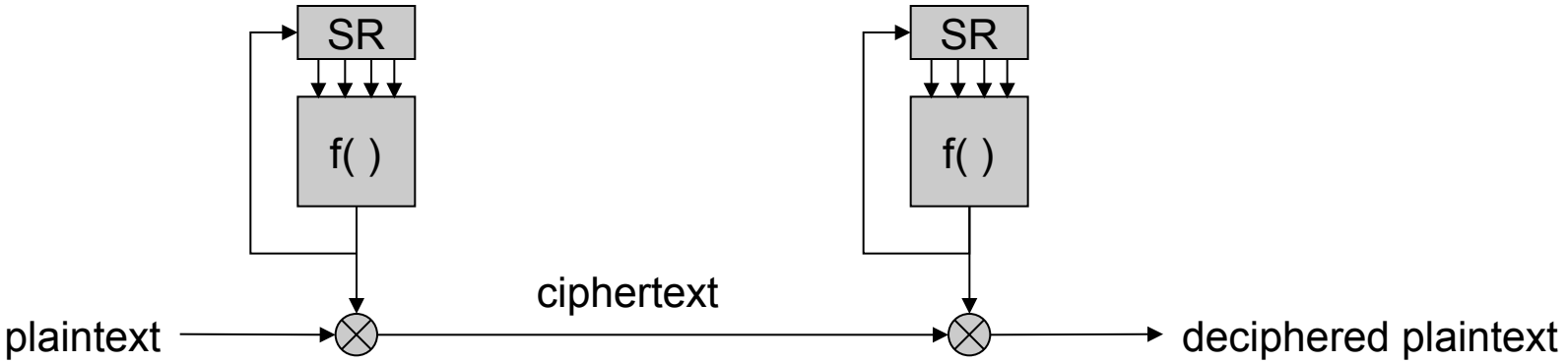
Generating Long Pseudo-Random Sequences

- How to make f( ) easy to change?
- What about synchronization?





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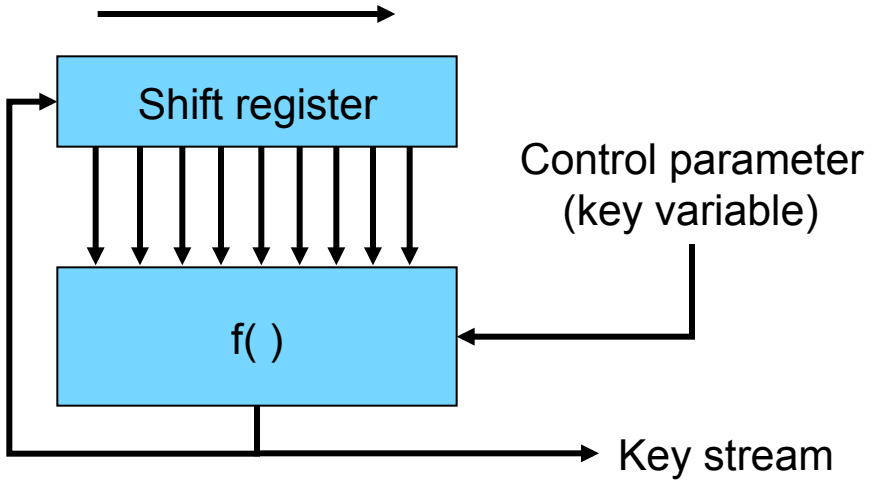

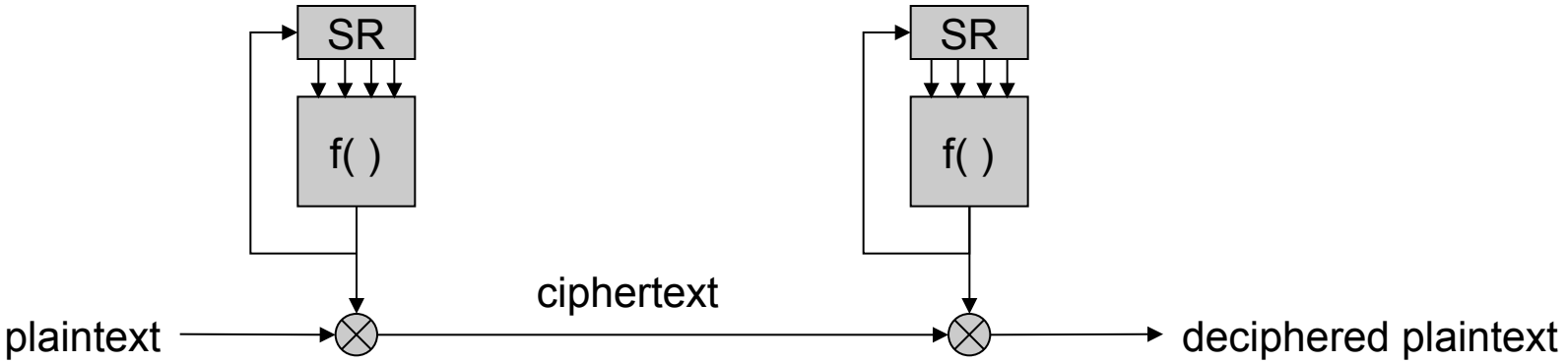

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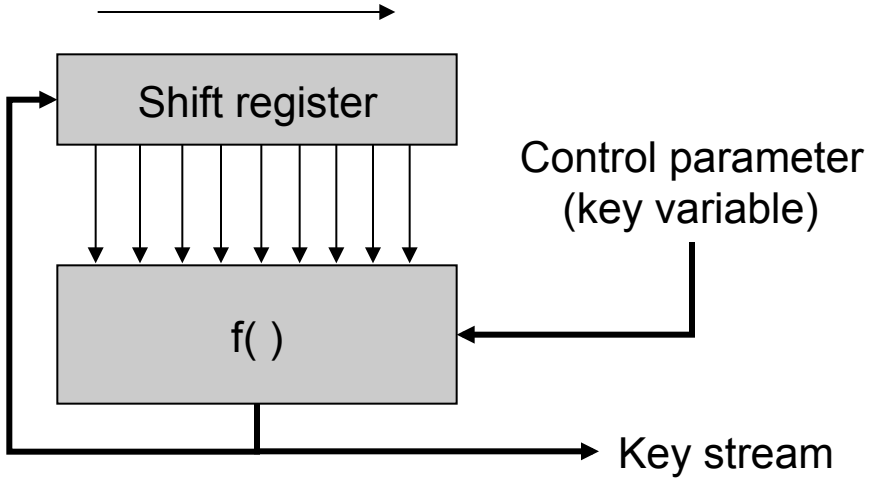

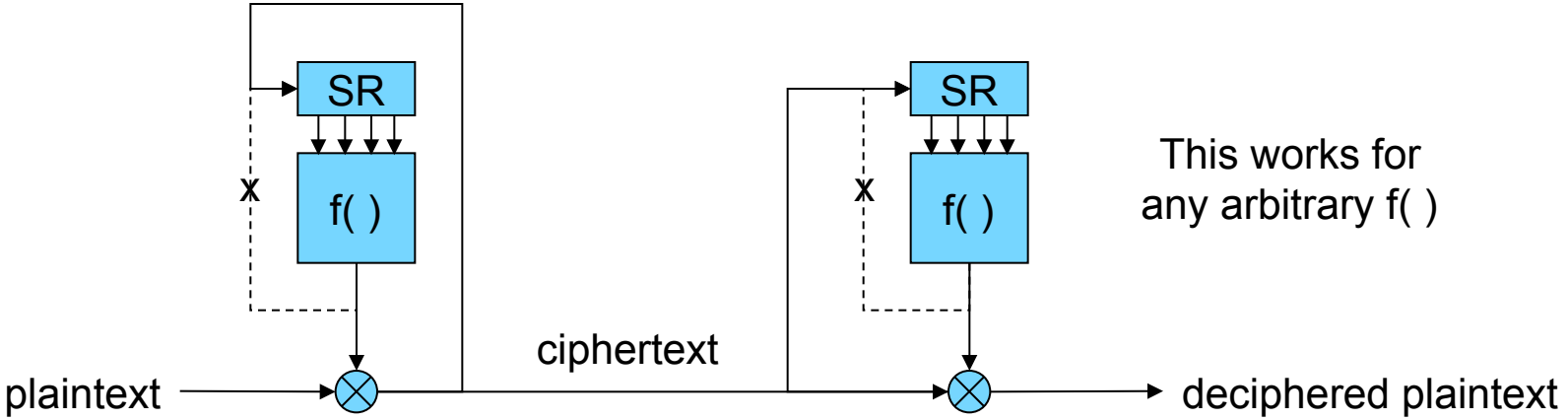

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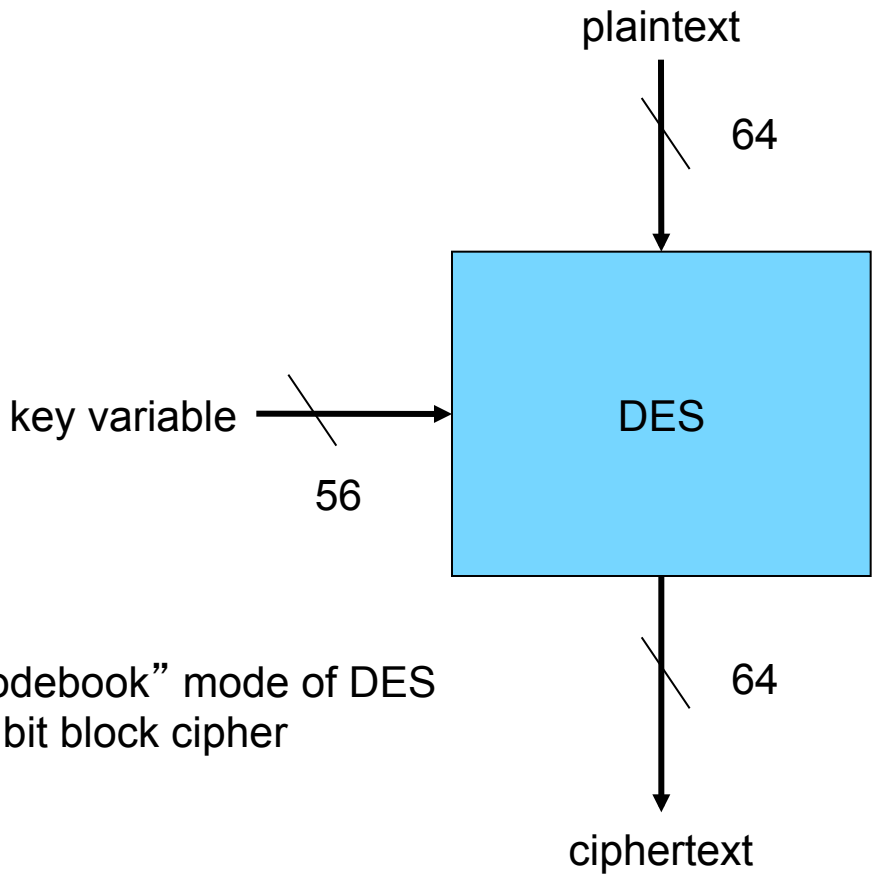
DES as one f( ) option



"Electronic codebook" mode of DES
– 64 bit block cipher

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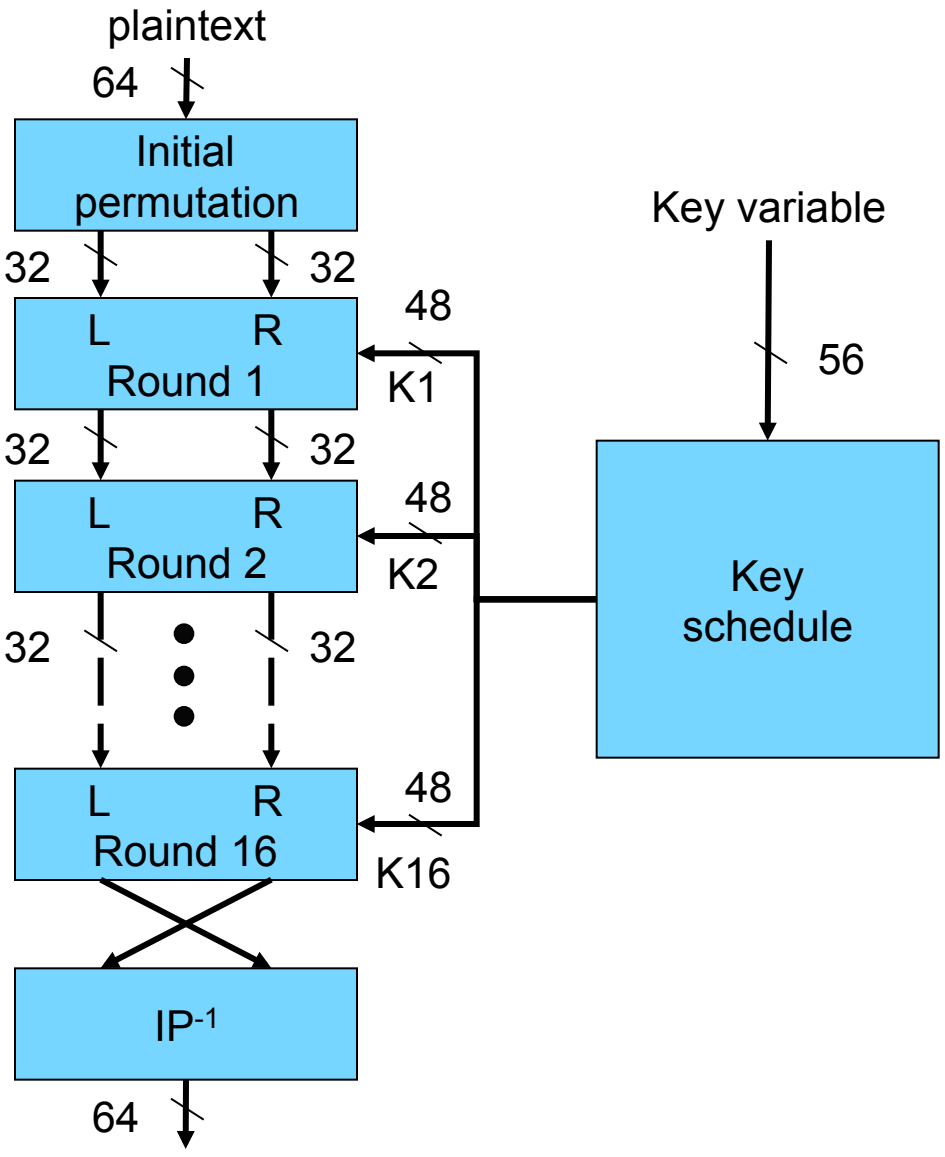
Internal operation of DES



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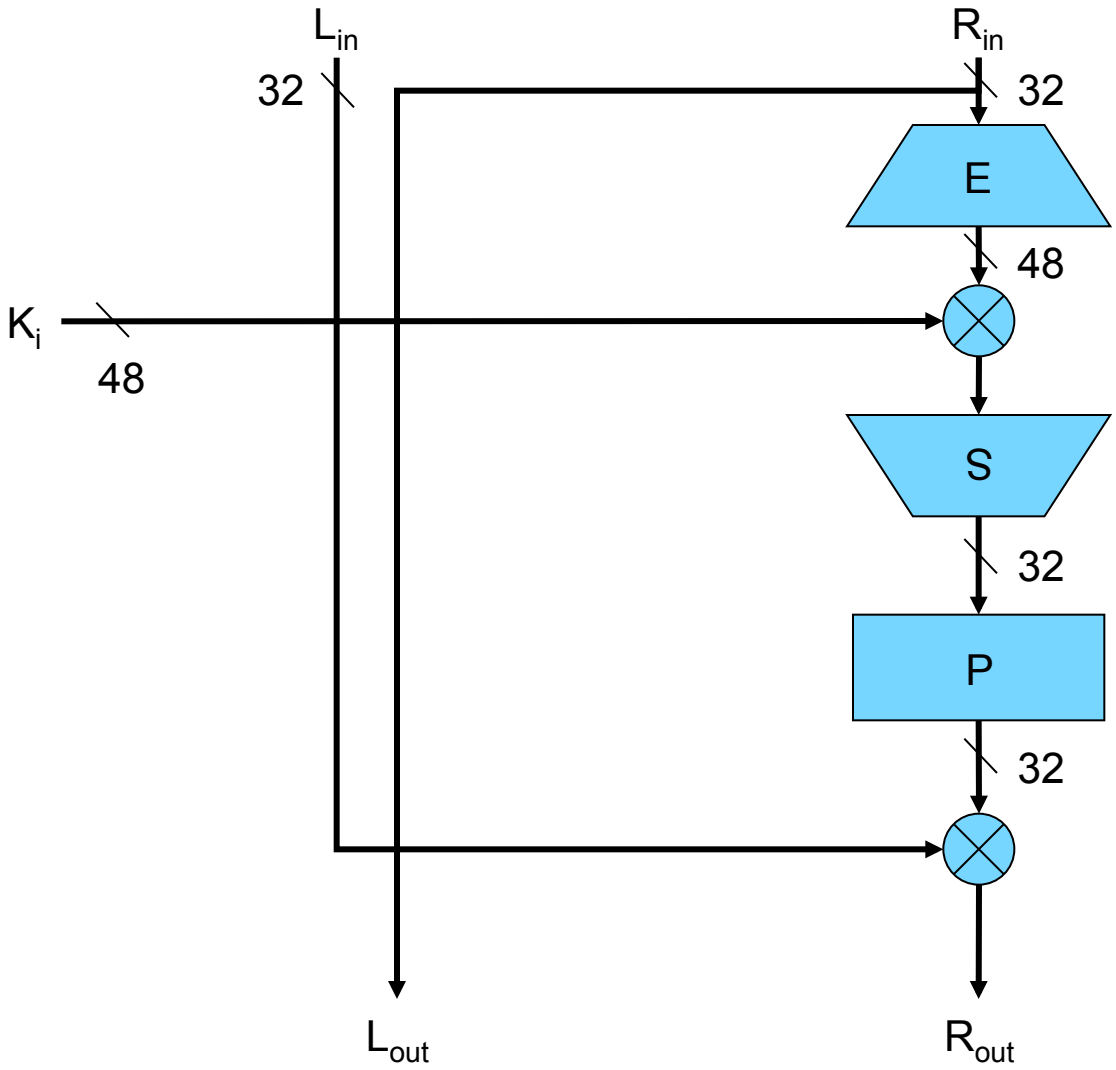
DES Round$_i$



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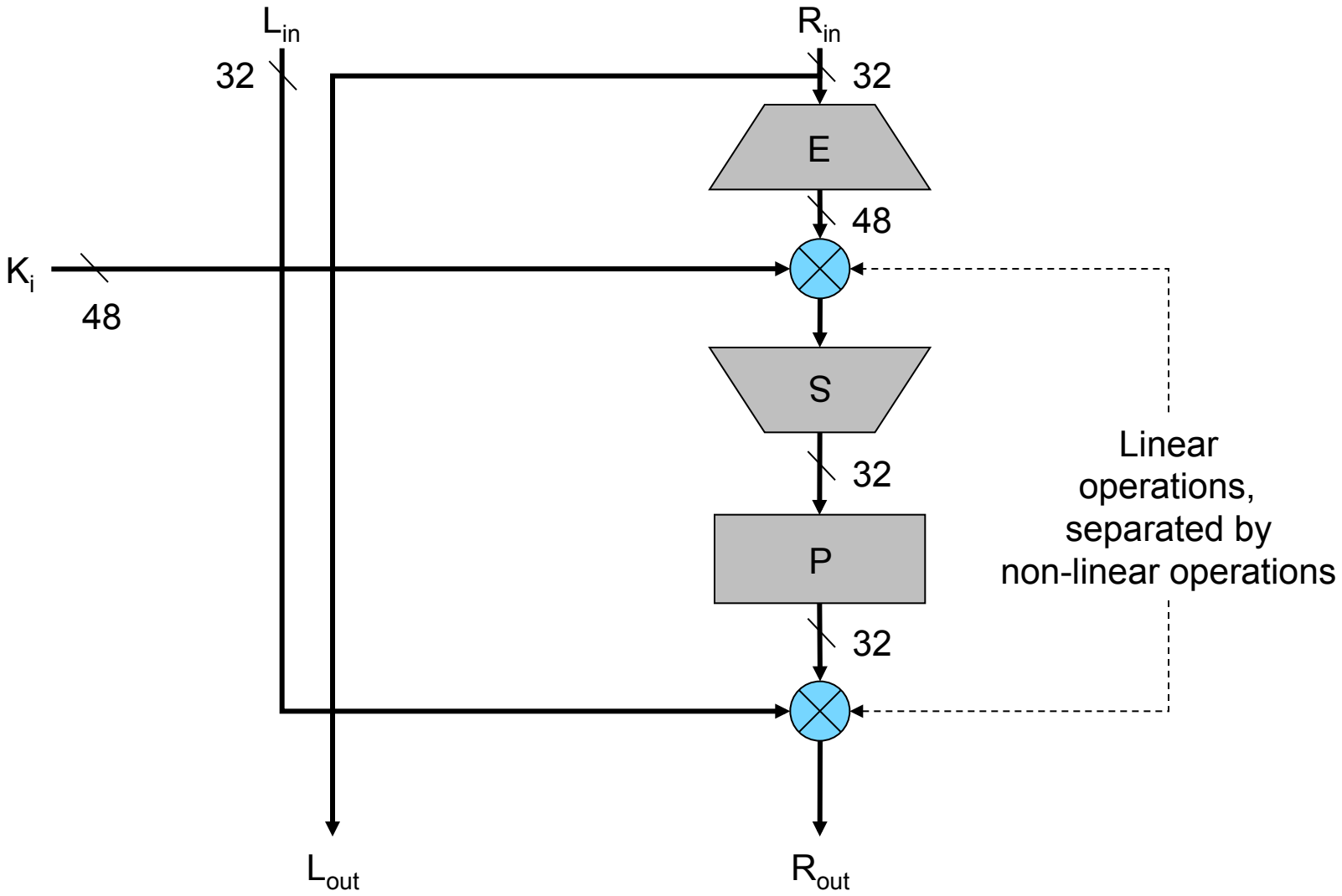

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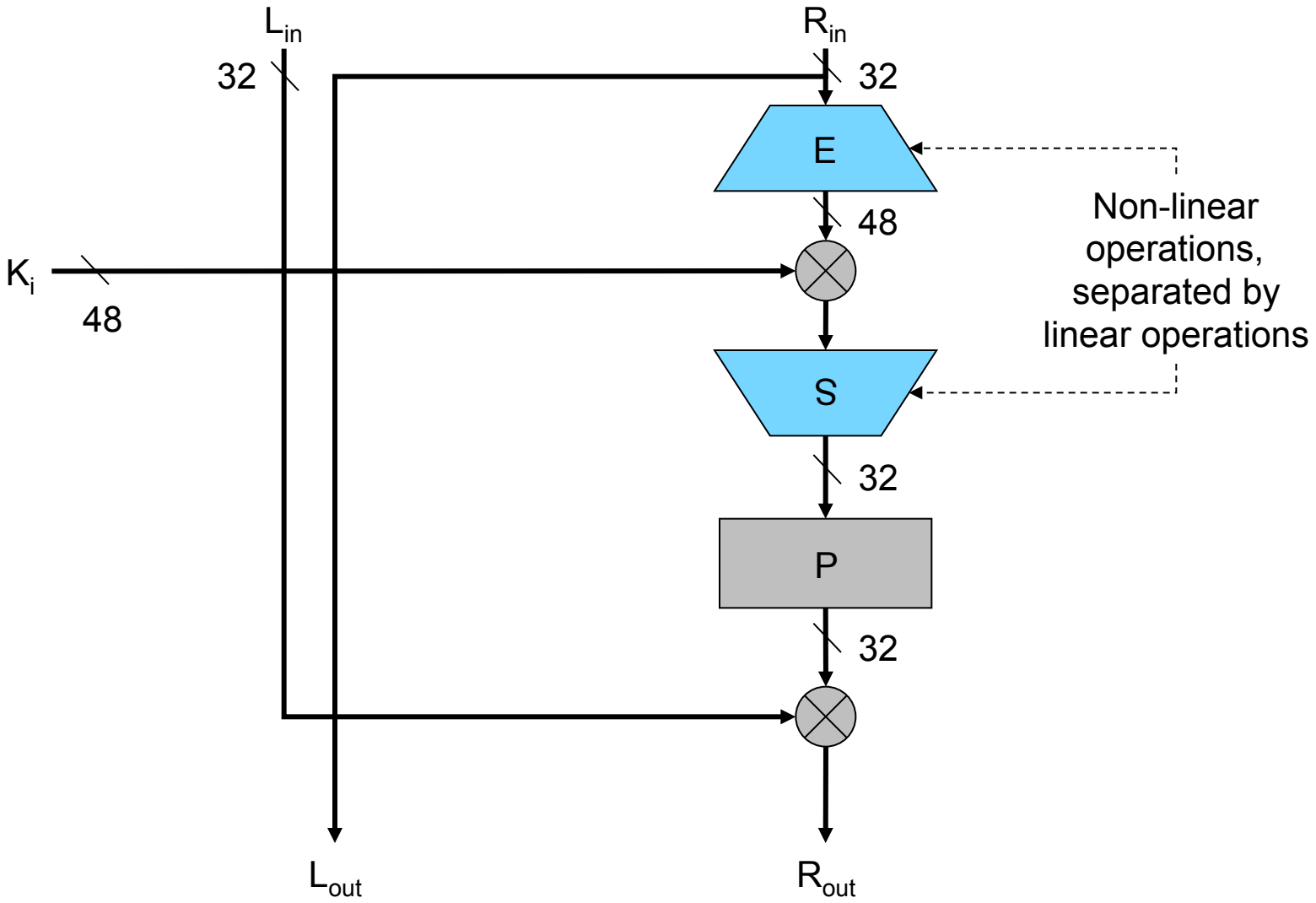

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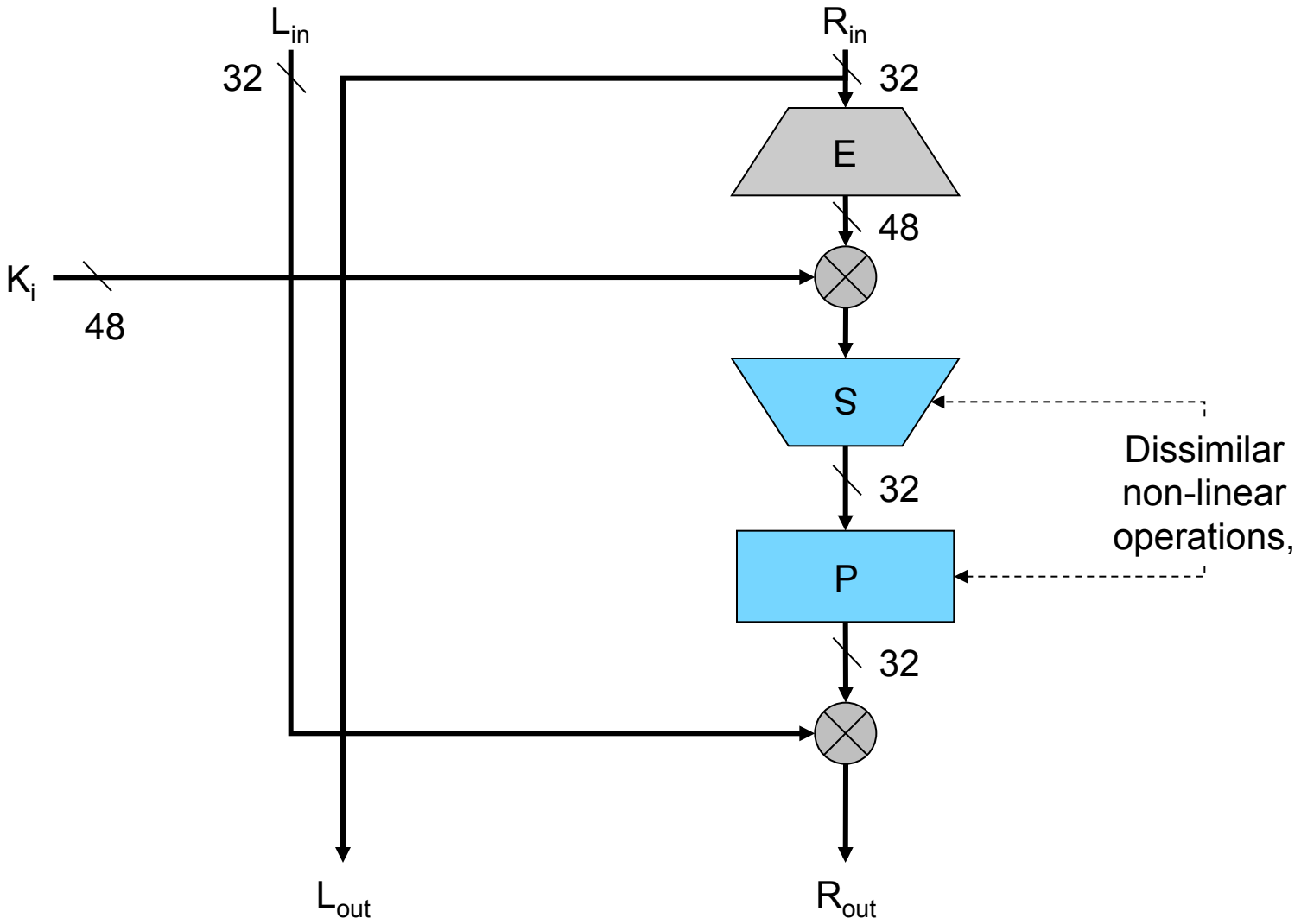

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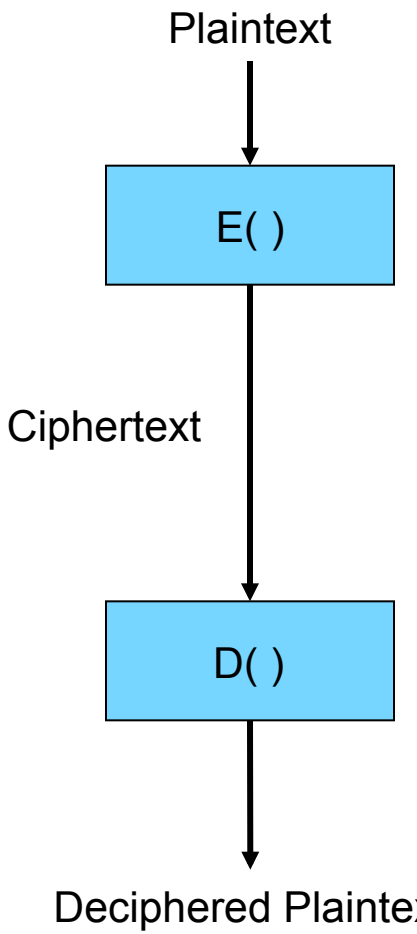
Public Key Cryptosystems



D(E(M)) = M

D( ) “cannot” be found, knowing E( ), and vice versa

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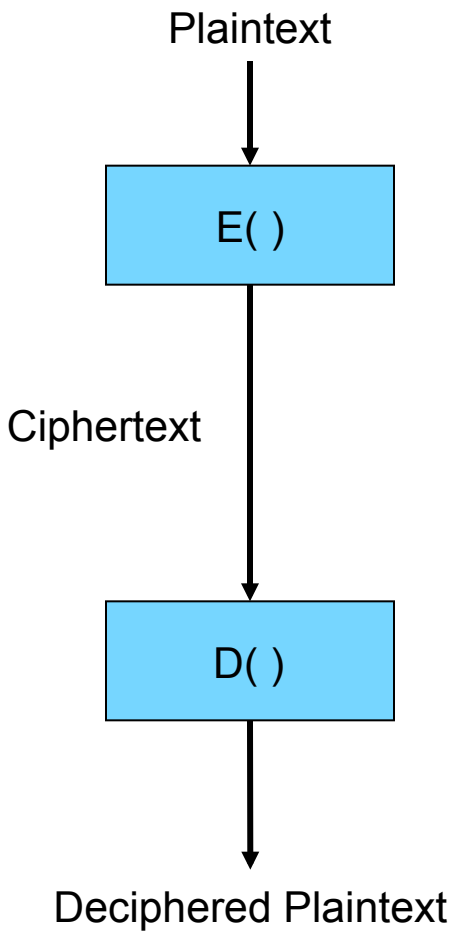

- D( ) and E( ) must be built on commutative functions:
  $f(g(x)) = g(f(x))$
- Multiplication and exponentiation work – are there others?
  These form bases for Rivest-Shamir-Adleman (RSA) and Diffie-Hellman PKCs
- The apparent security of PKCs come from difficulty of computing logarithms and factoring composite numbers in a finite field. ***Thought*** to be NP-Complete problems, Which ***might*** make them mathematically intractable
- E.g.,
  $E(M) = M^e$
  $D(C) = C^d$
  $D(E(M)) = (M^e)^d = M^{ed} = M^1$, if $d=e^{-1}$ in the field

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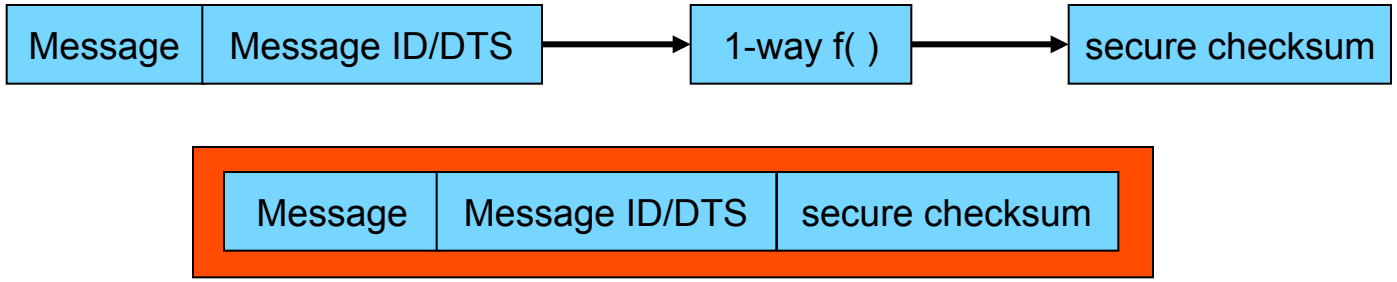
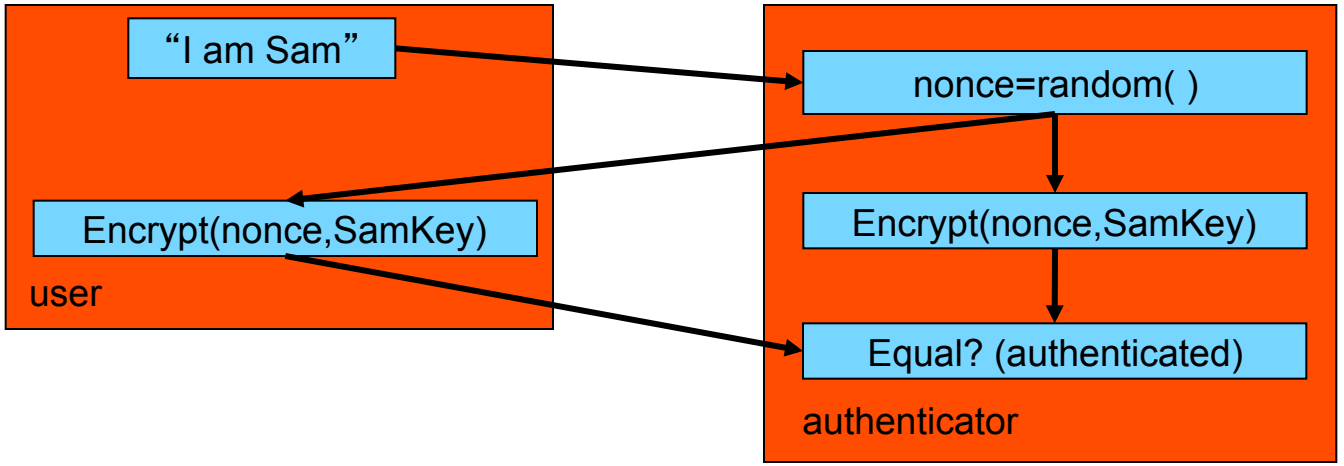
Applications of cryptography to security

- Confidentiality – the most obvious application
- Integrity



- Non-repudiation
  - Same as integrity, but seal the message: with user ID and user-specific key
- Authentication Challenge-response



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