Cryptography and Network Security Chapters 7

- Fifth Edition by William Stallings
- Lecture slides by Lawrie Brown

Stream Ciphers and Random Number Generation

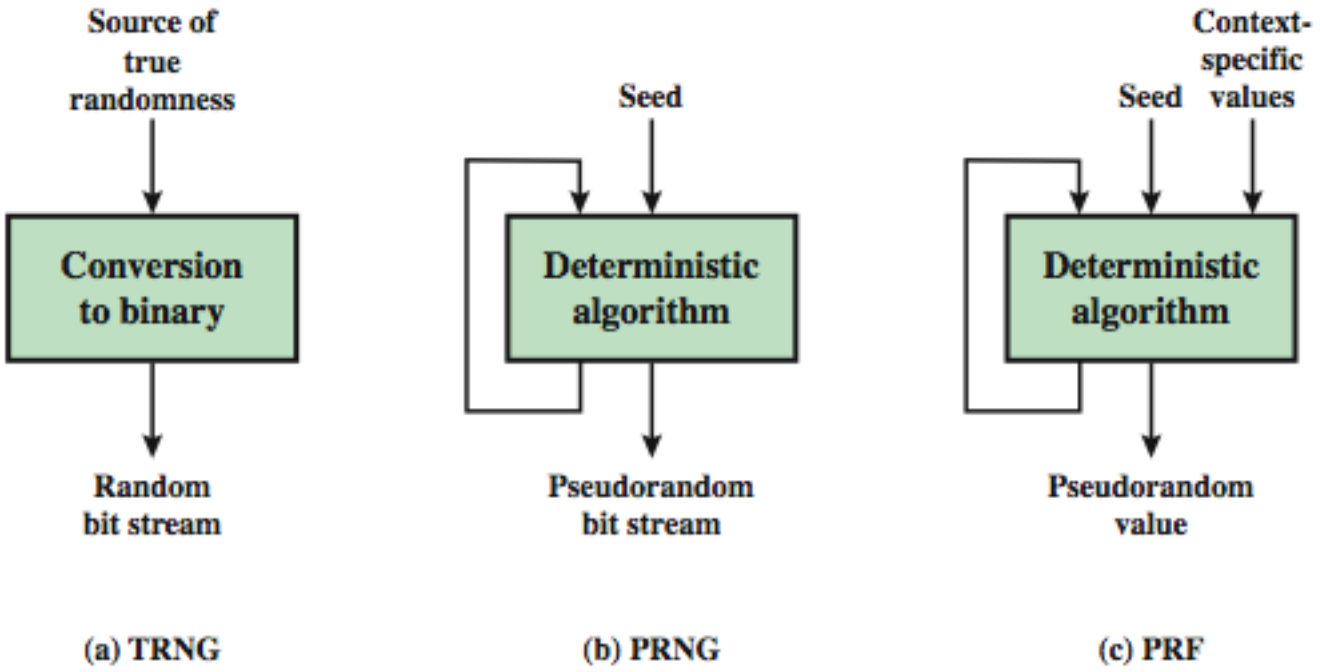
Random Numbers

- many uses of **random numbers** in cryptography
  - nonces in authentication protocols to prevent replay
  - session keys
  - public key generation
  - keystream for a one-time pad
- in all cases its critical that these values be
  - statistically random, uniform distribution, independent
  - unpredictability of future values from previous values
- true random numbers provide this
- care needed with generated random numbers

Pseudorandom Number Generators (PRNGs)

- often use deterministic algorithmic techniques to create "random numbers"
  - although are not truly random
  - can pass many tests of "randomness"
- known as "pseudorandom numbers"
- created by "Pseudorandom Number Generators (PRNGs)"

Random & Pseudorandom Number Generators



PRNG Requirements

- randomness
  - uniformity, scalability, consistency
- unpredictability
  - forward & backward unpredictability
  - use same tests to check
- characteristics of the seed
  - secure
  - if known adversary can determine output
  - so must be random or pseudorandom number

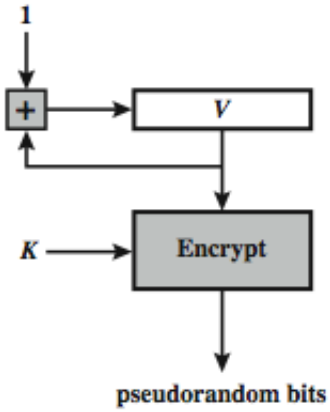
Using Block Ciphers as PRNGs

- for cryptographic applications, can use a block cipher to generate random numbers
- often for creating session keys from master key
- CTR

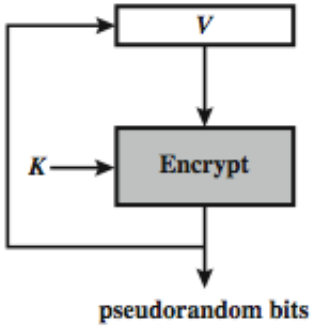
$$X_i = \mathrm{E}_K[\mathrm{V}_i]$$

- OFB

$$X_i = \mathrm{E}_K[X_{i-1}]$$



(a) CTR Mode

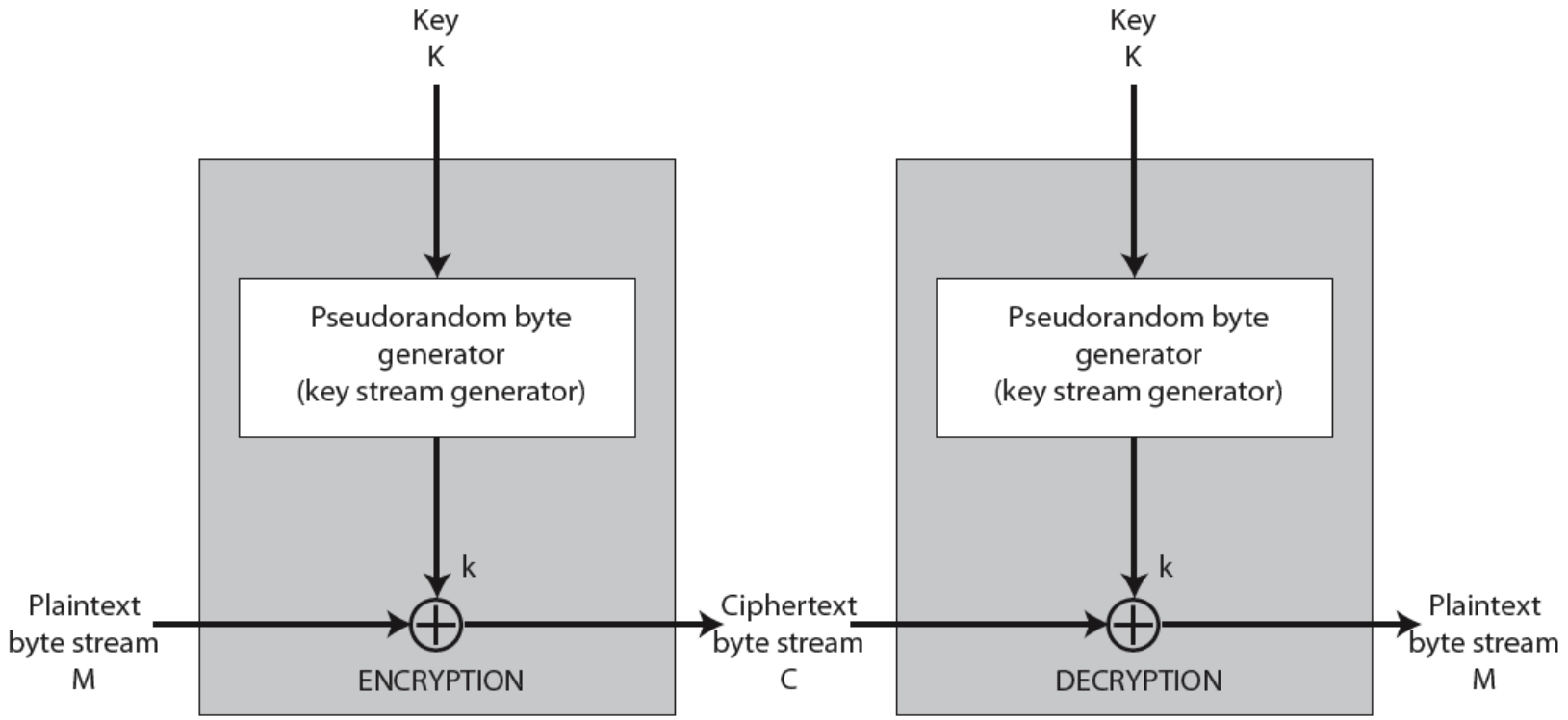


(b) OFB Mode

Stream Ciphers

- process message bit by bit (as a stream)
- have a pseudo random **keystream**
- combined (XOR) with plaintext bit by bit
- randomness of **stream key** completely destroys statistical properties in message
  - $C_i = M_i \text{ XOR } StreamKey_i$
- but must never reuse stream key
  - otherwise can recover messages

Stream Cipher Structure



Stream Cipher Properties

- some design considerations are:
  - long period with no repetitions
  - statistically random
  - depends on large enough key
  - large linear complexity
- if properly designed, can be as secure as a block cipher with same size key
- but usually simpler & faster

RC4

- a proprietary cipher owned by RSA DSI
- another Ron Rivest design, simple but effective
- variable key size, byte-oriented stream cipher
- widely used, e.g. in the web SSL/TLS protocol

Conclusion

Have considered:

- Random numbers
- Pseudorandom numbers generators
- Stream ciphers