Block Cipher Operation

CSS441: Security and Cryptography

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Thammasat University

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Cipher Block Chaining Mode

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Modes of Operation

- Block cipher: operates on fixed length b-bit input to produce b-bit ciphertext
- What about encrypting plaintext longer than b bits?
- Break plaintext into b-bit blocks (padding if necessary) and apply cipher on each block
- Security issues arise: different modes of operation have been developed

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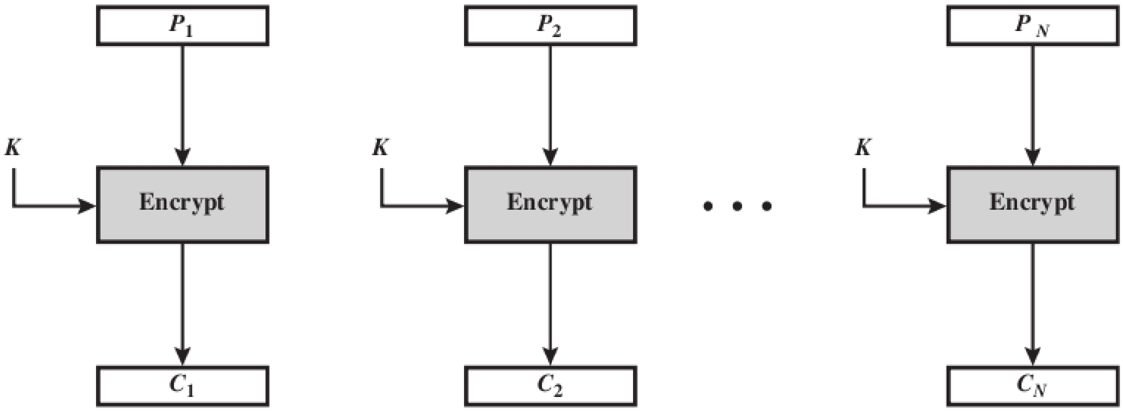
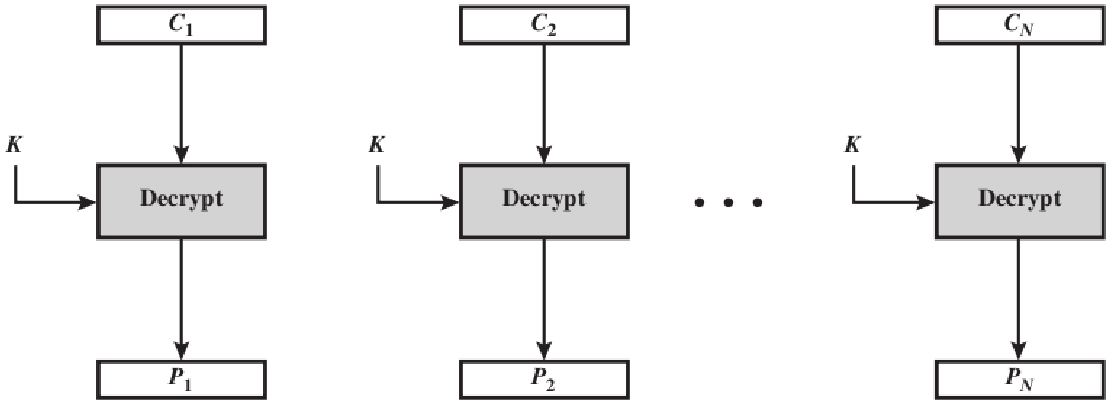
ECB Encryption



ECB Decryption



Summary

- Each block of 64 plaintext bits is encoded independently using same key
- Typical applications: secure transmission of single values (e.g. encryption key)
- Problem: with long message, repetition in plaintext may cause repetition in ciphertext

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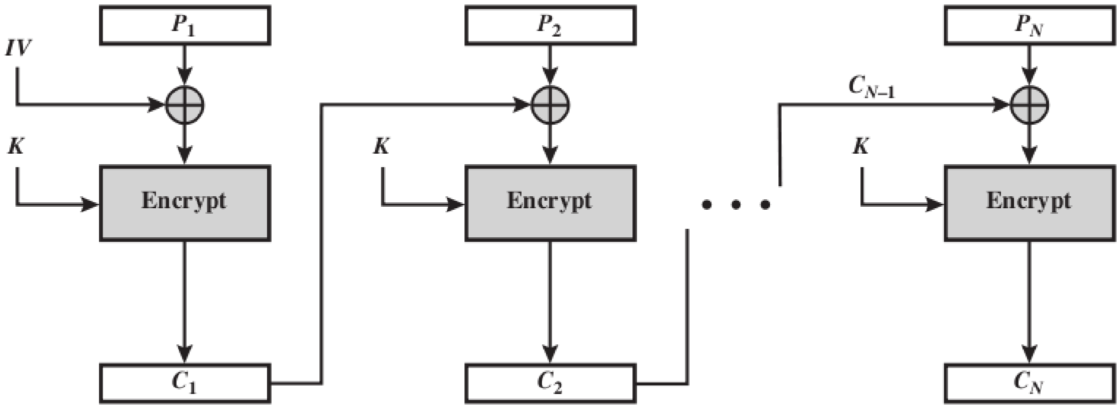
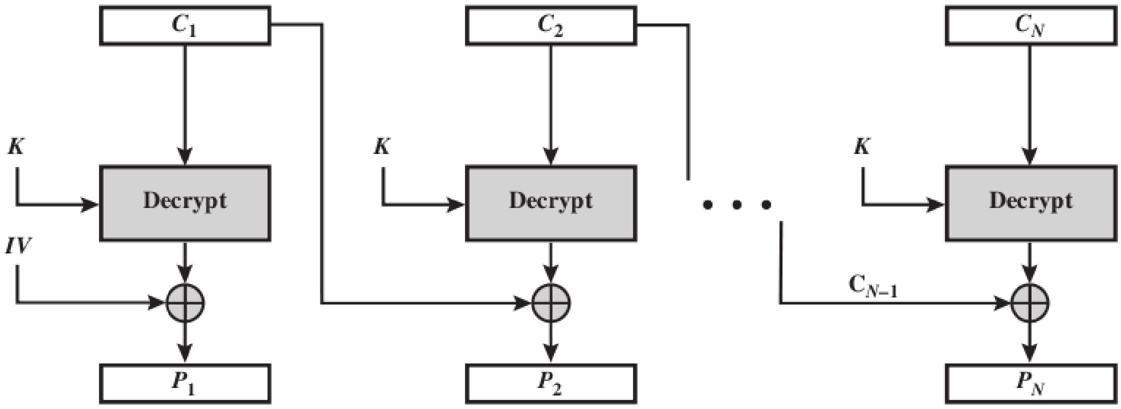


CBC Decryption



CBC Summary

- Input to encryption algorithm is XOR of next 64-bits plaintext and preceding 64-bits ciphertext
- Typical applications: General-purpose block-oriented transmission; authentication
- Initialisation Vector (IV) must be known by sender/receiver, but secret from attacker

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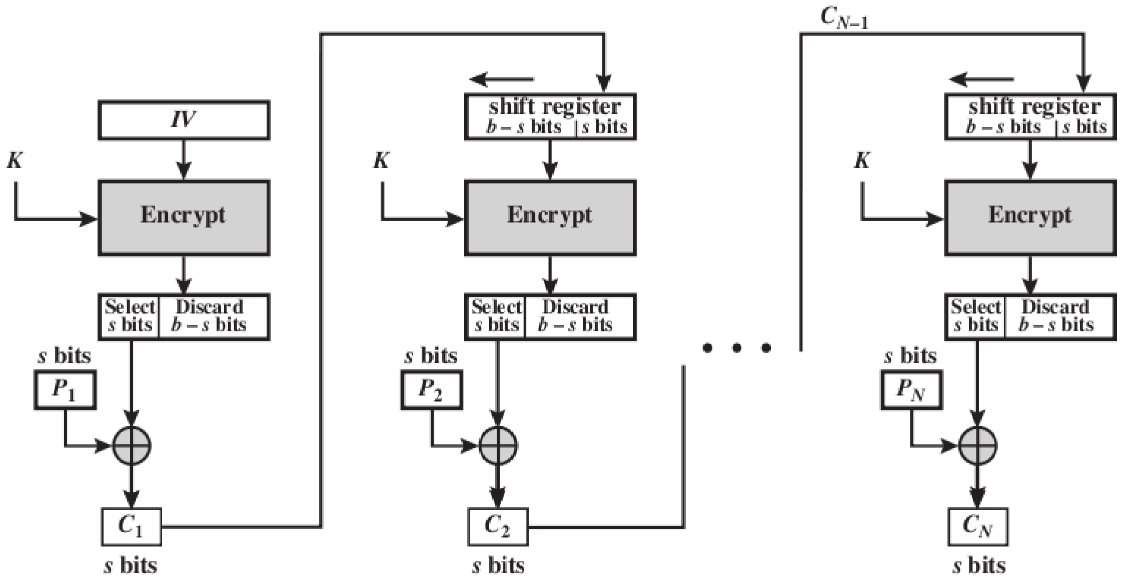
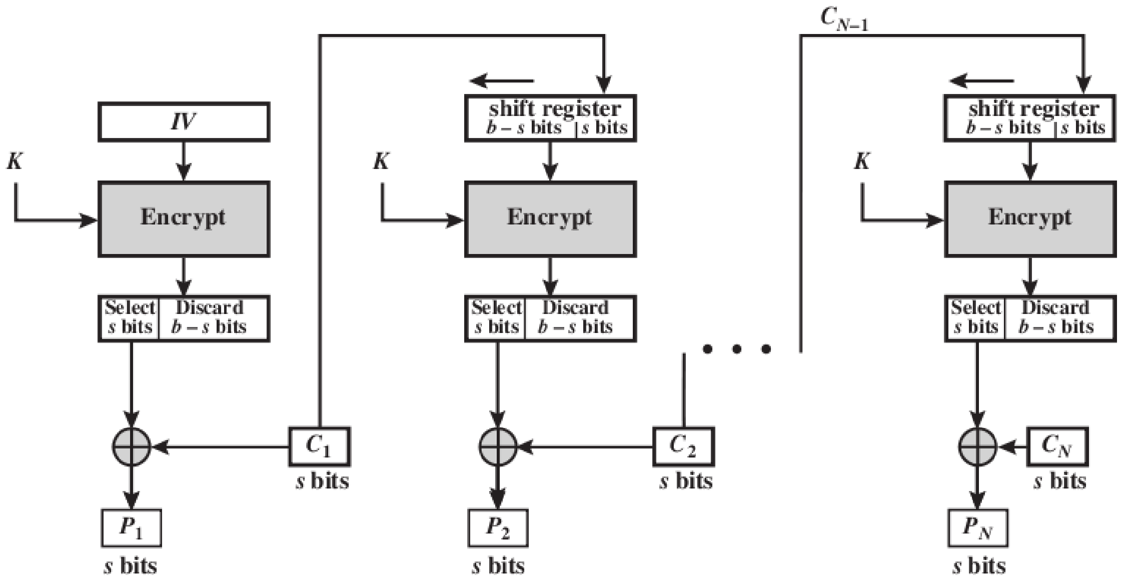


CFB Decryption



CFB Summary

- Converts block cipher into stream cipher
  - No need to pad message to integral number of blocks
  - Operate in real-time: each character encrypted and transmitted immediately
- Input processed *s* bits at a time
- Preceding ciphertext used as input to cipher to produce pseudo-random output
- XOR output with plaintext to produce ciphertext
- Typical applications: General-purpose stream-oriented transmission; authentication

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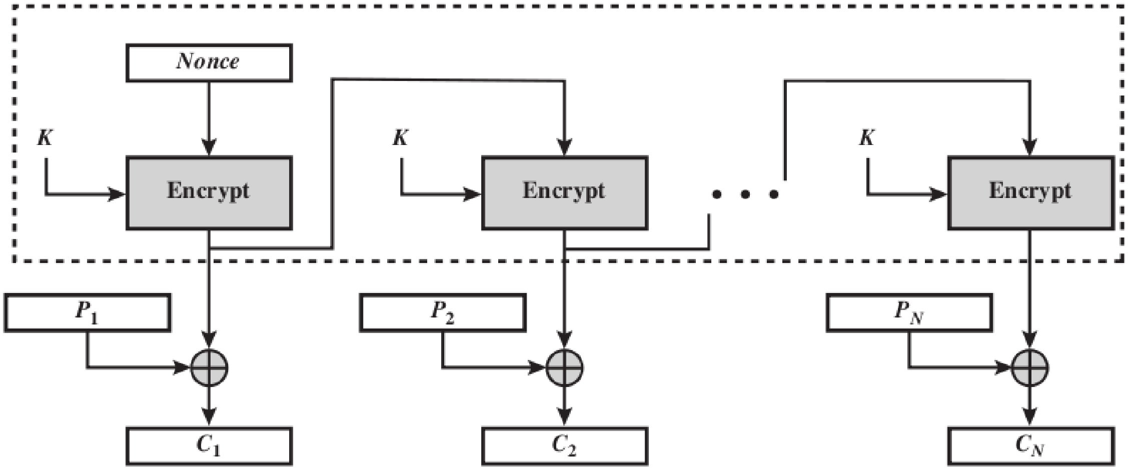
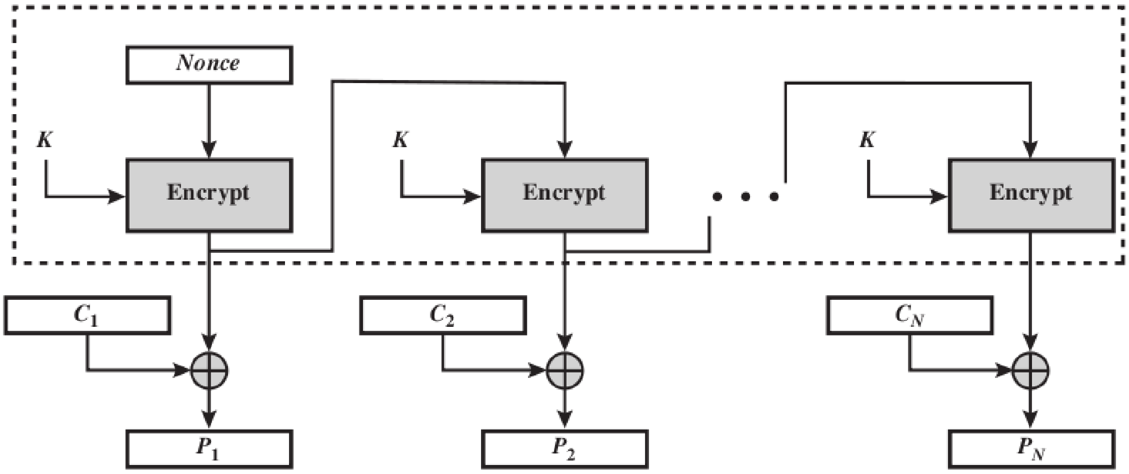


OFB Decryption



OFB Summary

- Converts block cipher into stream cipher
- Similar to CFB, except input to encryption algorithm is preceding encryption output
- Typical applications: stream-oriented transmission over noisy channels (e.g. satellite communications)
- Advantage compared to OFB: bit errors do not propagate
- Disadvantage: more vulnerable to message stream modification attack

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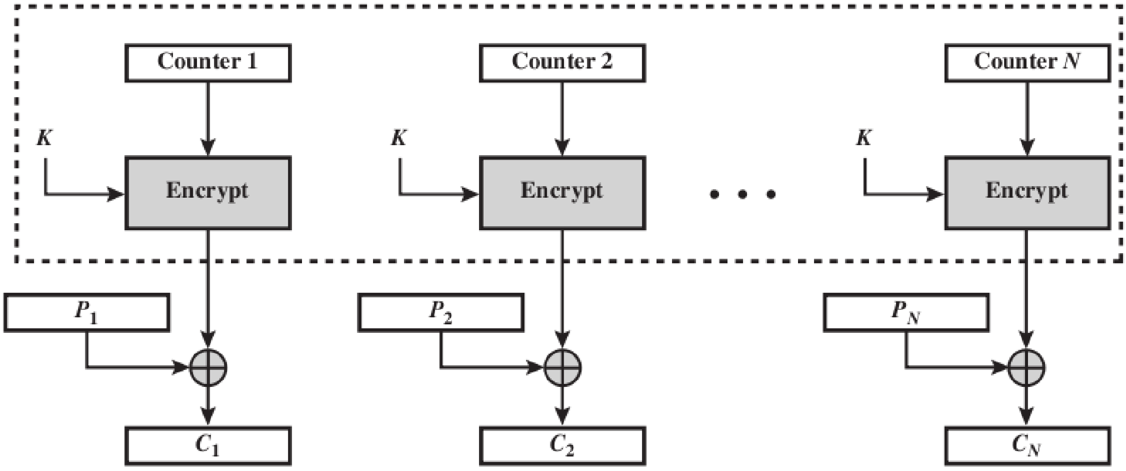
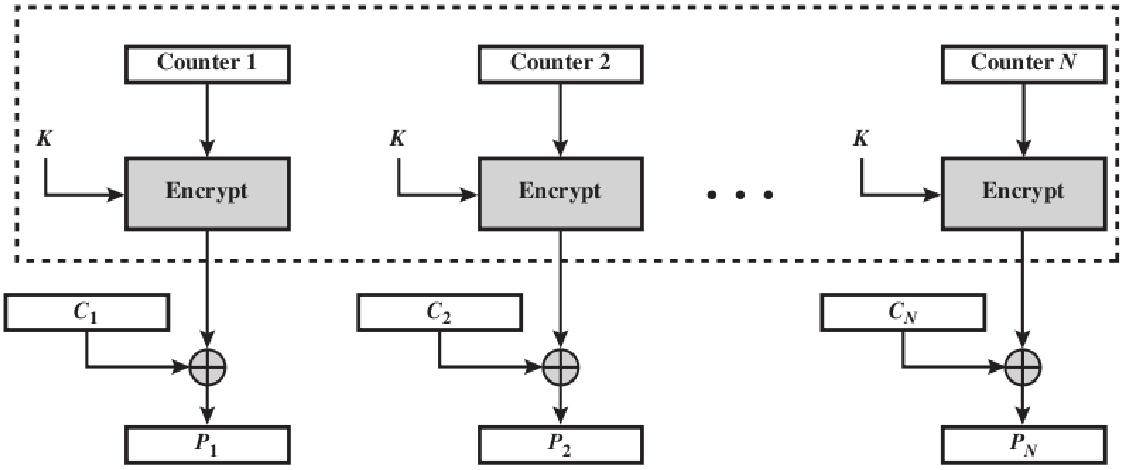


CTR Decryption



CTR Summary

- Converts block cipher into stream cipher
- Each block of plaintext XORed with encrypted counter
- Typical applications: General-purpose block-oriented transmission; useful for high speed requirements
- Efficient hardware and software implementations
- Simple and secure

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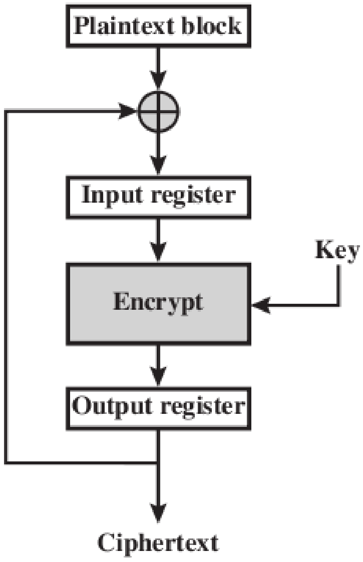
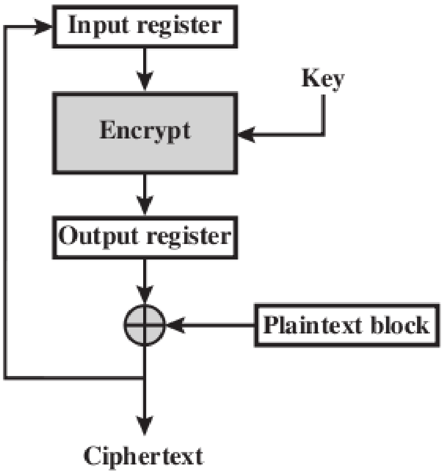
Feedback: CBC and CFB

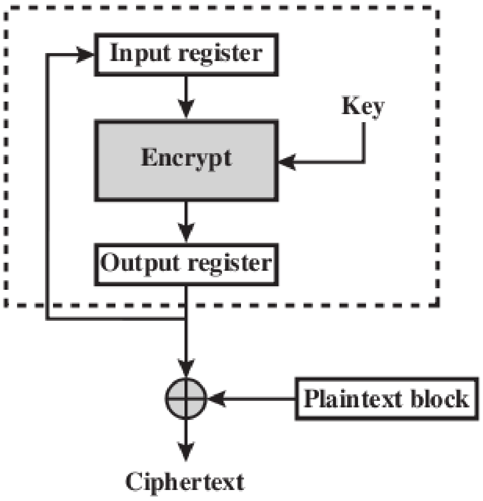


(a) Cipher block chaining (CBC) mode

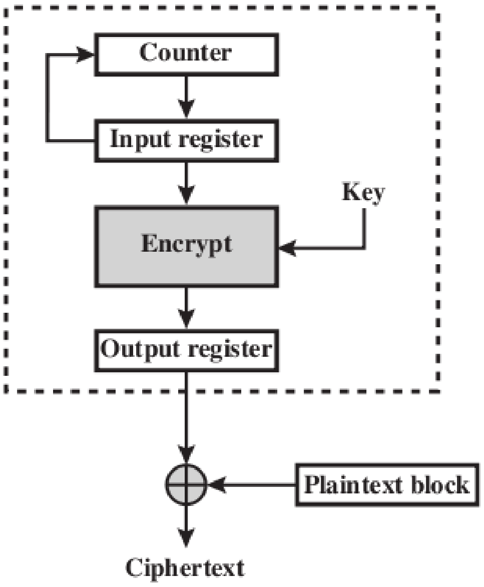


(b) Cipher feedback (CFB) mode

Feedback: OFB and CTR



(c) Output feedback (OFB) mode



(d) Counter (CTR) mode

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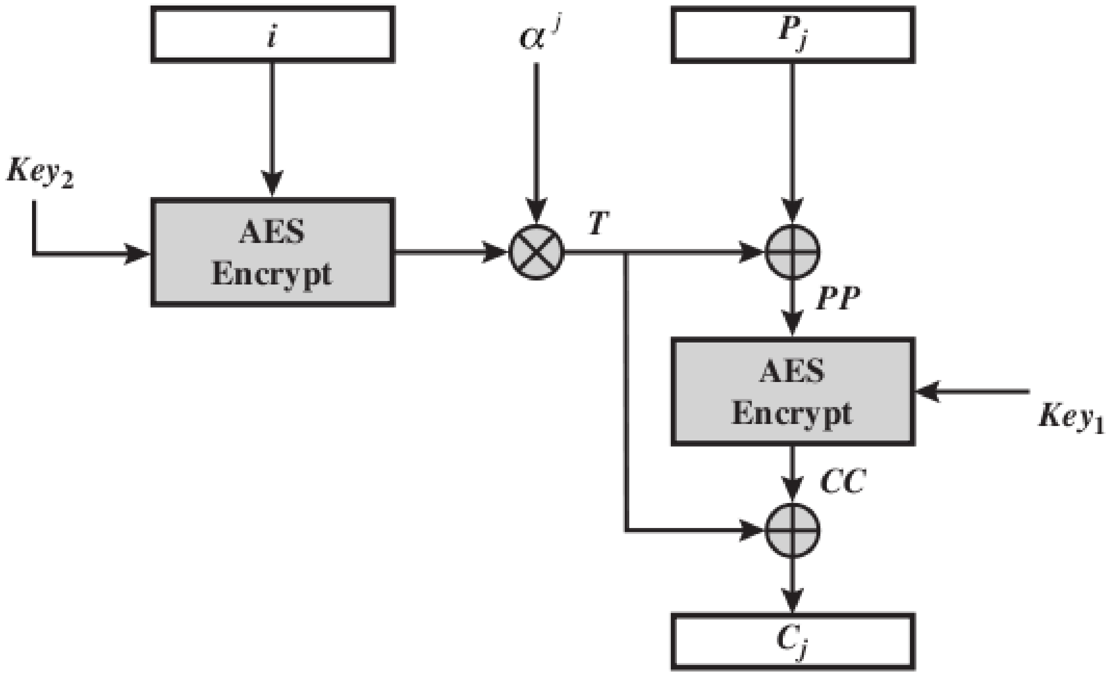
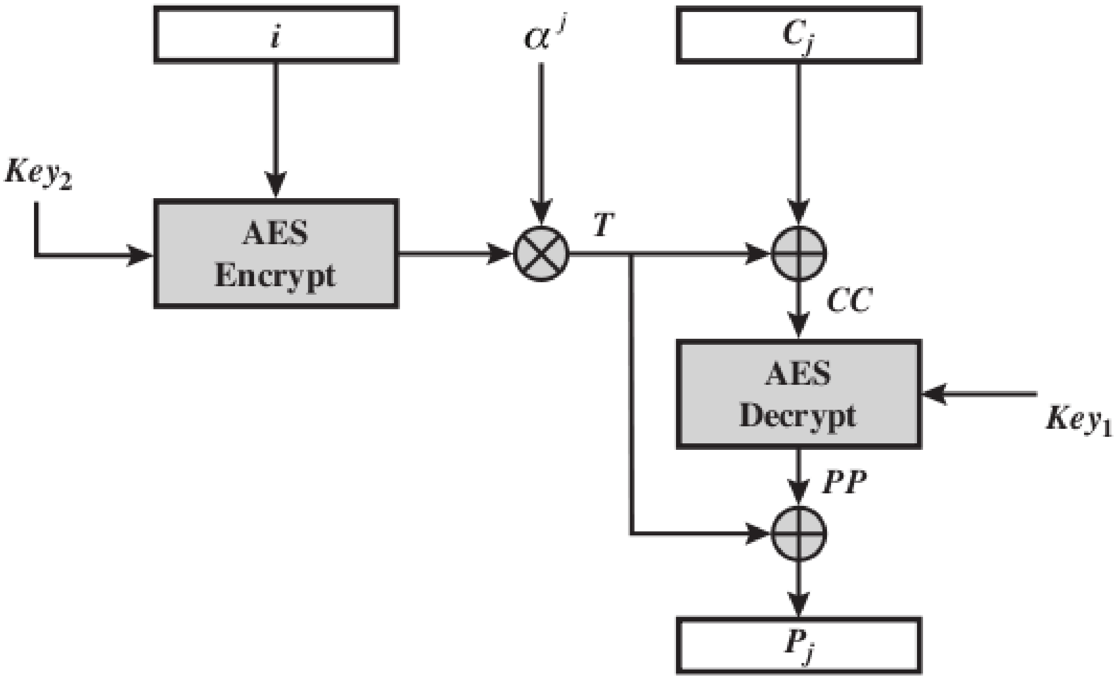
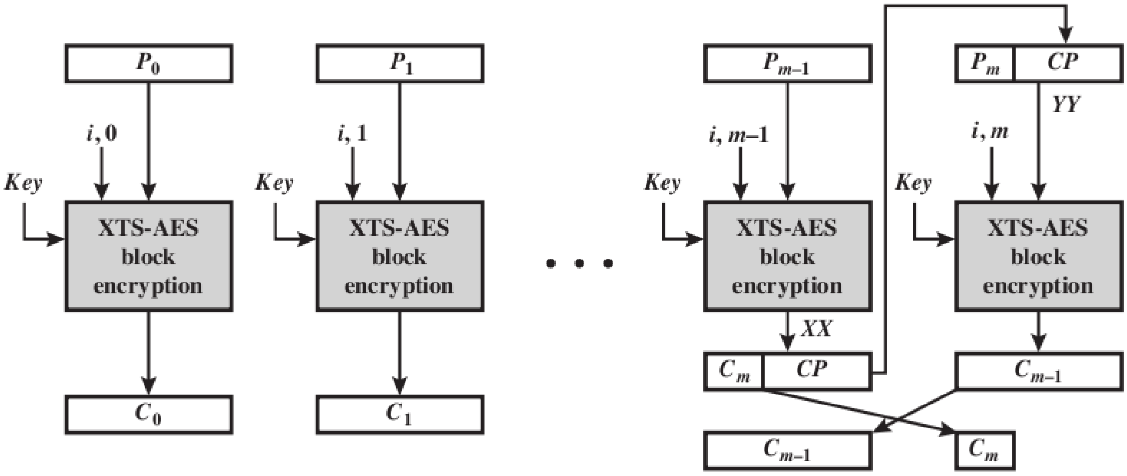
XTS-AES Encryption of Single Block



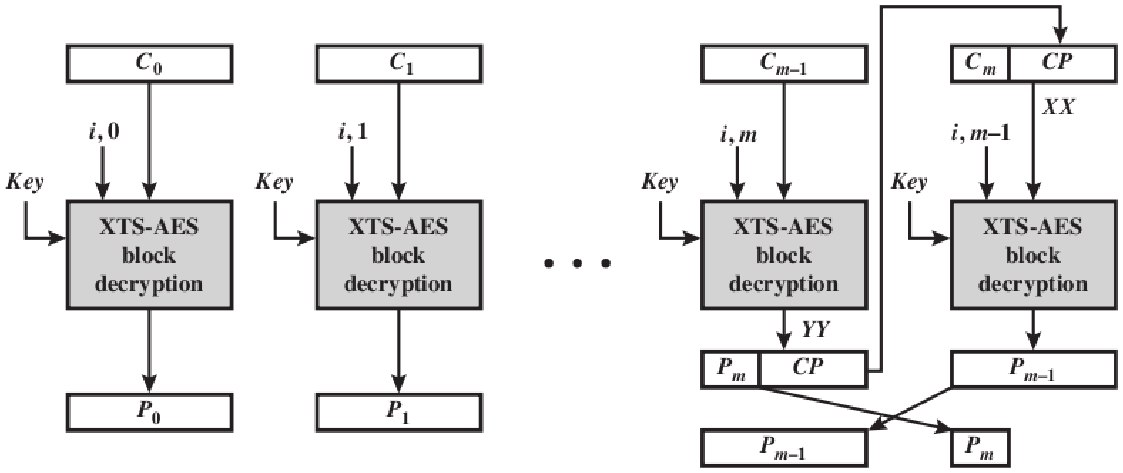
XTS-AES Decryption of Single Block



XTS-AES Encryption



XTS-AES Decryption



Encryption for Stored Data

- XTS-AES designed for encrypting stored data (as opposed to transmitted data)
- See Chapter 6.7 for details and differences to transmitted data encryption