Comparing Cryptographic Modes of Operation using Flow Diagrams

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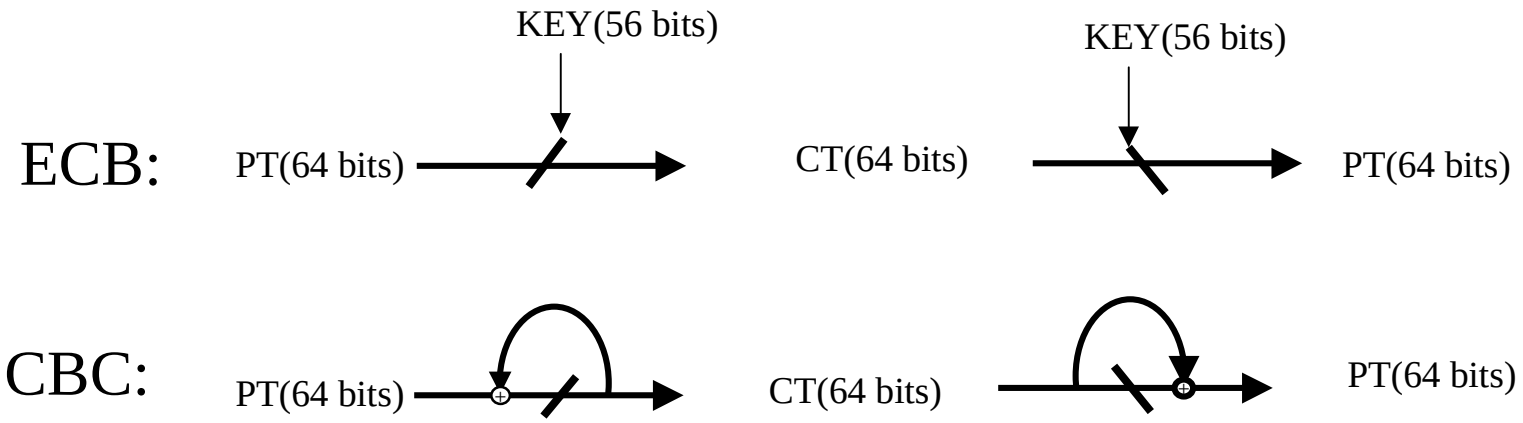
Simplified Flow Diagrams for study of Cryptographic "Modes of Operation"

- To contrast and understand the major characteristics of standard and proposed standard modes
  - Gloss over some of the fine details such as:
    - Initial Variables
    - Checksum Calculations
    - Key Management/Manipulation Details

Encryption usually involves a Nonlinear "Block Cipher"

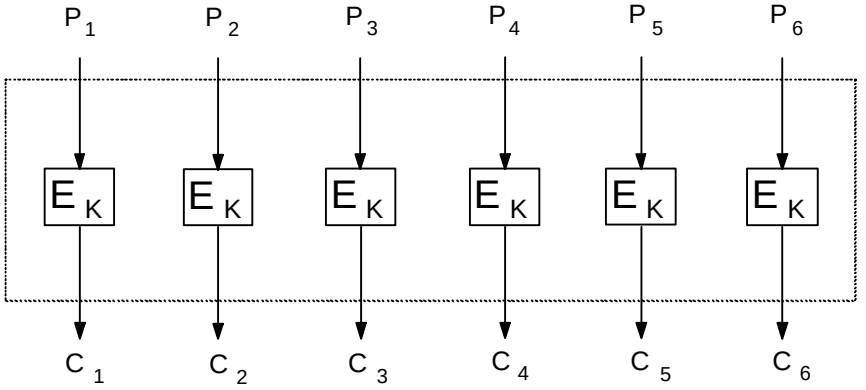
- The Nonlinear Block Cipher is depicted here by a "slanted line": /
- The inverse (Decryption) is depicted by the "opposite slant": \
- Data flows through the Nonlinear Block Cipher in various "modes of operation". For example, with DES:



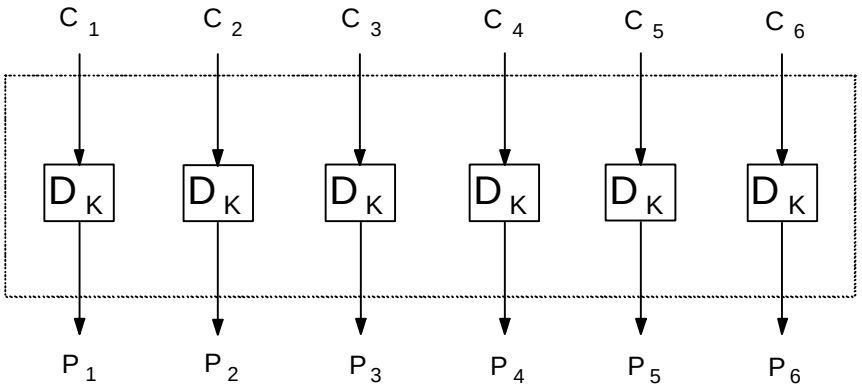
Electronic CodeBook (ECB)

ECB Mode

Encryption



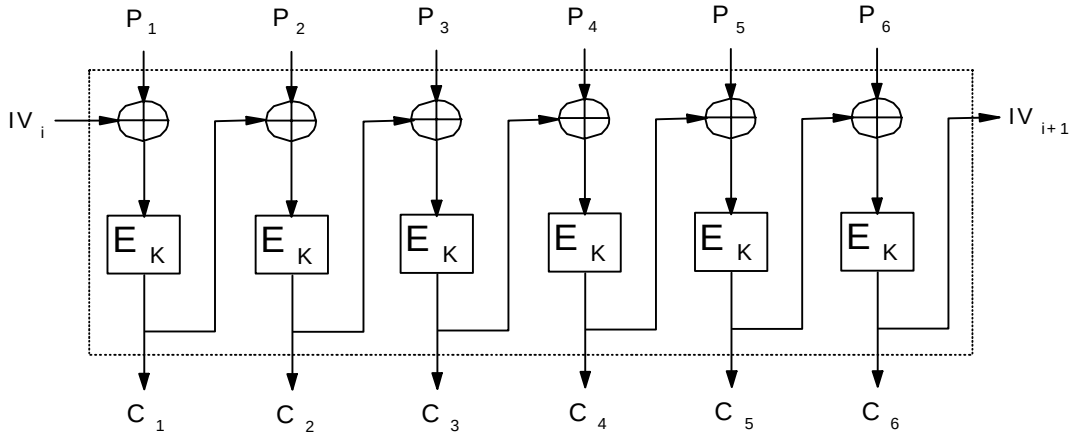
Decryption



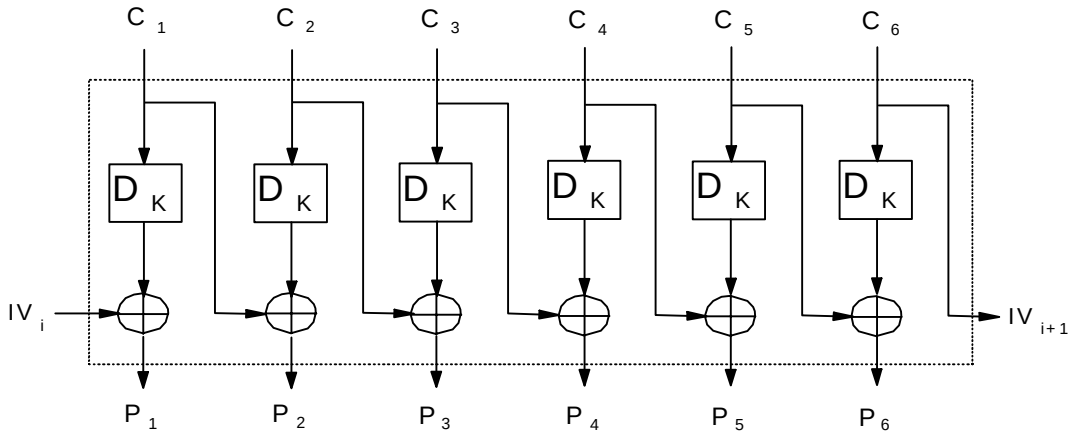
Cipher Block Chaining (CBC)

CBC Mode

Encryption



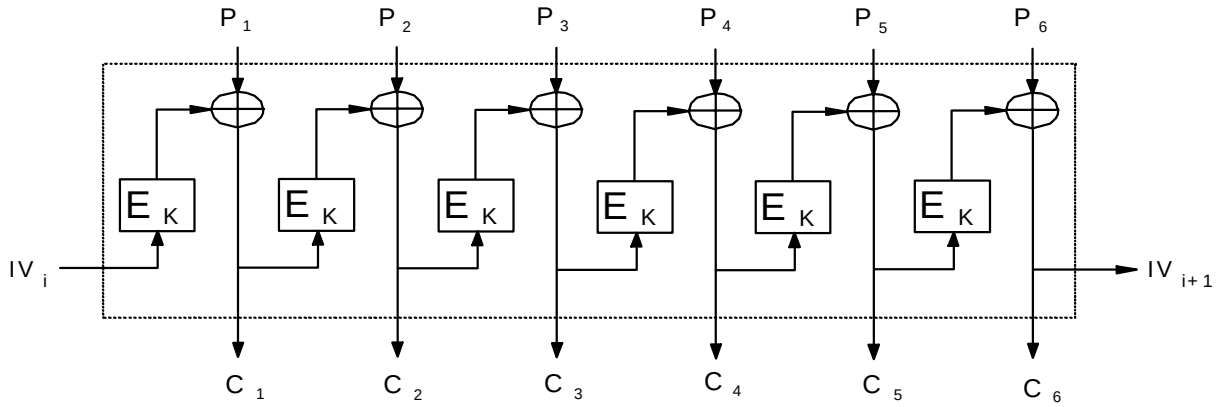
Decryption



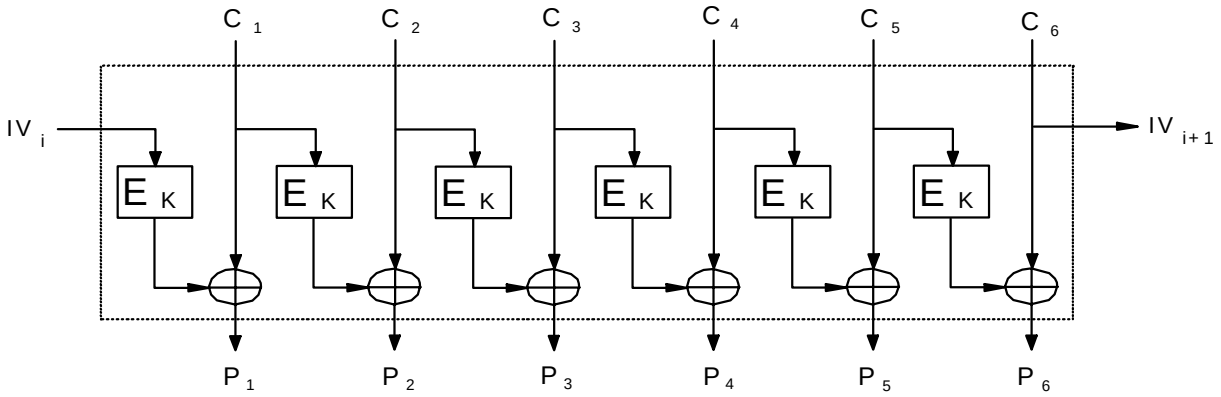
Cipher FeedBack (CFB)

CFB Mode

Encryption



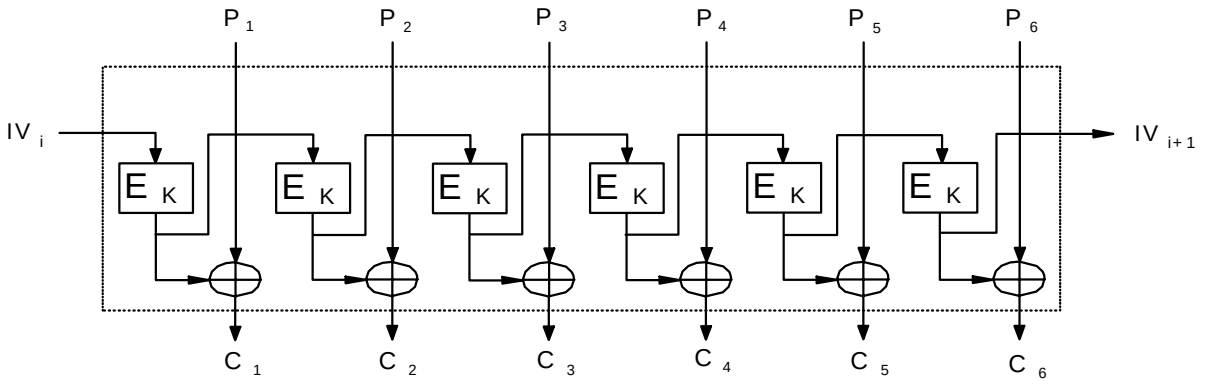
Decryption



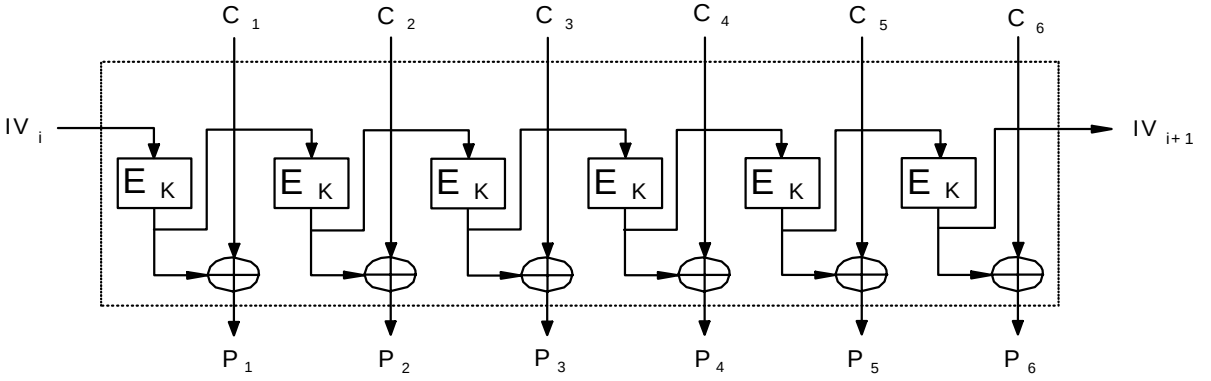
Output FeedBack

O F B M o d e

E n c r y p t i o n



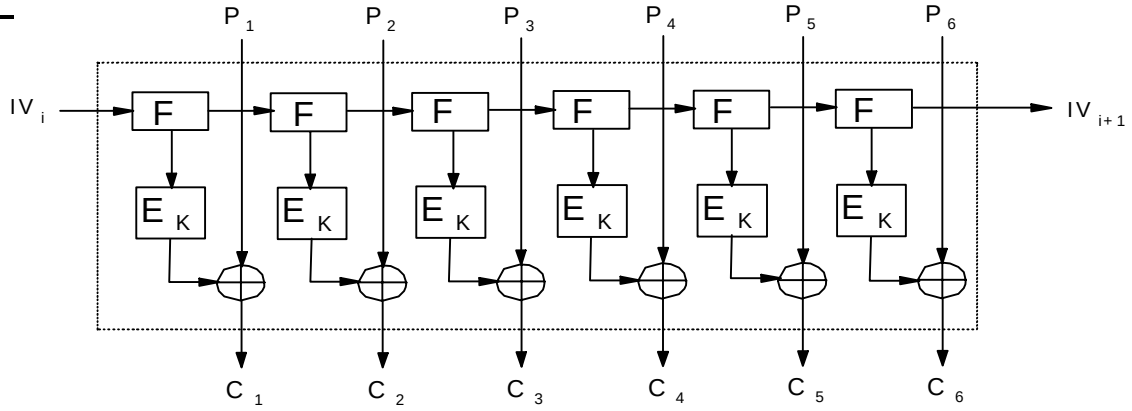
D e c r y p t i o n



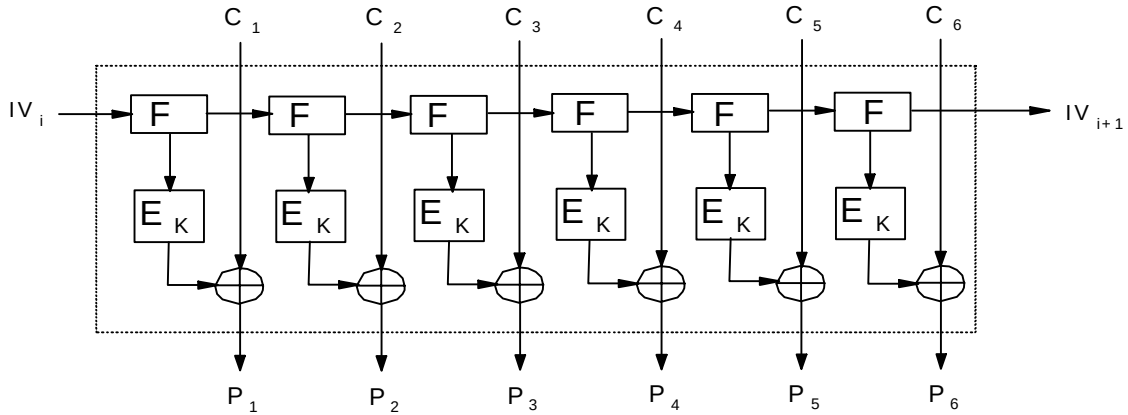
Counter Mode

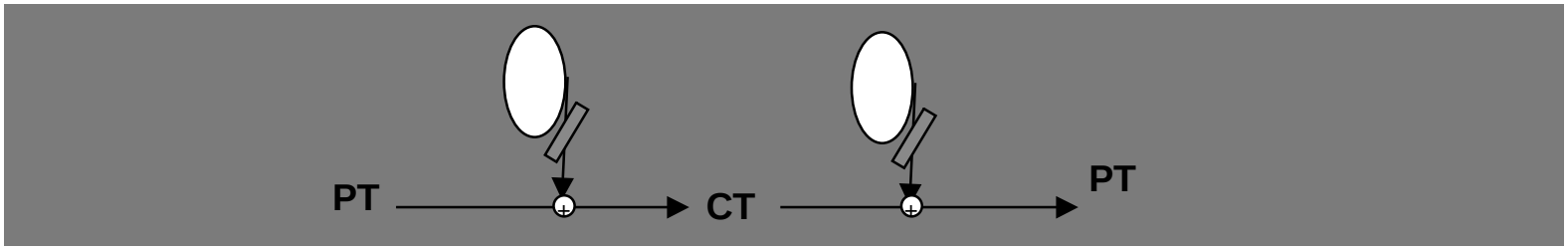
Counter Mode

Encryption



Decryption

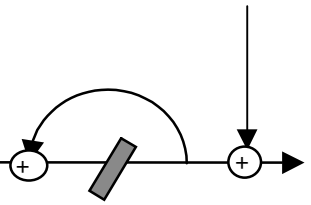




“Almost Free Integrity” Modes

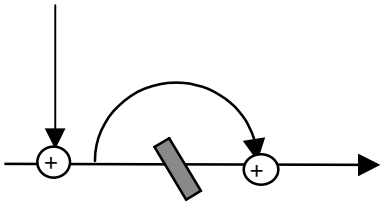
[pre-whitening sequence]

PT



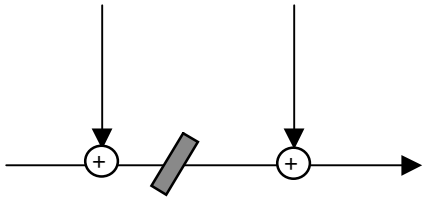
[pre-whitening sequence]

CT

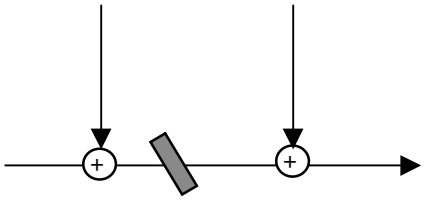


PT

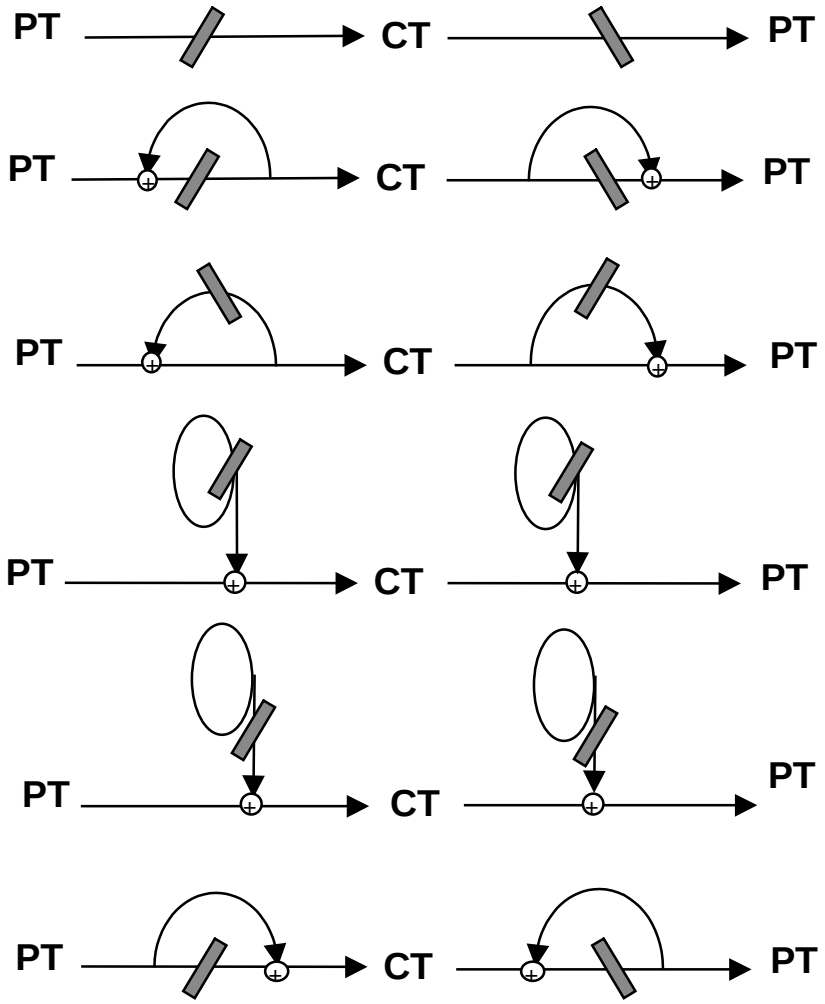
[pre & post whitening sequences]



[pre & post whitening sequences]



Encryption Modes of Operation



- Electronic CodeBook (ECB)
- Cipher Block Chaining (CBC)
- Cipher FeedBack (CFB)
- Output FeedBack (OFB)
- Counter Mode (Filter Generator)
- Plaintext Block Chaining

Mode	Security	Implementation	Fault Tolerance	Crypto Sync
ECB	- plaintext patterns are not concealed	+ no feedback + no IV storage + encryption and decryption are parallelizable	+ bit loss has no additional negative effects - ciphertext error magnification	+ self synchronizing
CBC	+ plaintext patterns are concealed	- feedback from encryption output - IV storage - encryption is not parallelizable + decryption is parallelizable	+ bit loss causes 1 additional block of plaintext to be corrupted - ciphertext error magnification	+ self synchronizing
CFB	+ plaintext patterns are concealed	- feedback from encryption output - IV storage - encryption is not parallelizable + decryption is parallelizable	+ bit loss causes 1 additional block of plaintext to be corrupted - ciphertext error magnification	+ self synchronizing
OFB	+ plaintext patterns are concealed	- feedback from encryption output - IV storage - encryption and decryption are not parallelizable	- bit loss causes loss of crypto synchronization + no ciphertext error magnification	- requires periodic resynch