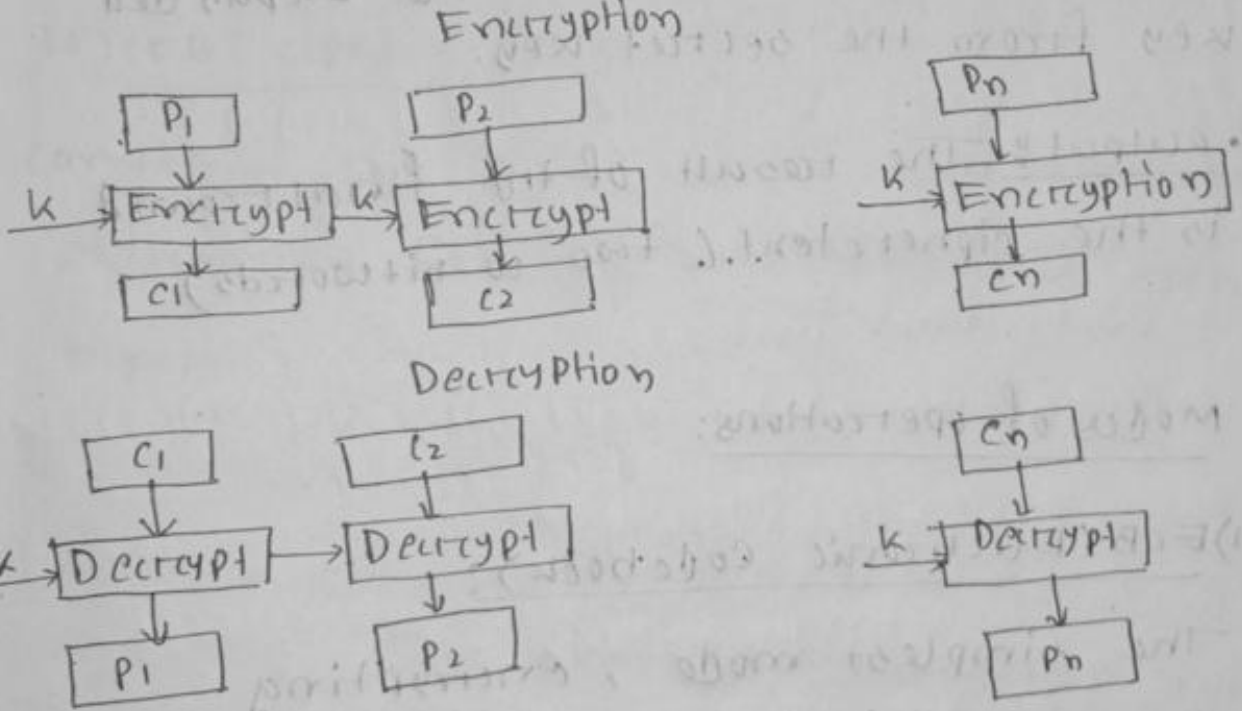
RC5: is a symmetric block cipher known for its simplicity and flexibility in key and block sizes.




RC5 Block Diagram:

- Input: The plaintext is divided into two words (w bits each)
- Initial Key Addition: The input words are combined with a portion of the expanded key

- Mixing (circular-shift°. These operations (XOR and Rotations) are applied iteratively in multiple rounds.
- Key schedule: Generates the expanded key from the secret key.
- Output: The result of the final round is the ciphertext (two w-bit words).

Modes of operations:

1) ECB (Electronic Codebook):

The simplest mode, encrypting each block independently, suitable for short, random data but can reveal patterns in non-random

ii) CBC (Cipher Block chaining):

Each block is XORed with the previous ciphertext block before encryption. Providing better security than ECB

iii) OFB (Output Feedback):

Uses the previous ciphertext block to generate the keystream, making it suitable for noisy channel.

iv) CFB (Cipher feedback):

Converts the block cipher into a stream cipher by feeding back previous ciphertext blocks.

v) Counter (CTR):

Uses a counter to generate the keystream allowing for parallel encryption and decryption.

## Java implementation of RC5:

```
import java.nio.ByteBuffer;
import java.util.Arrays;

public class RC5 {
private final int w= 32;
private final int r= 12;
private final int b = 16;
private final int[] s;
private final int pw = 0xb7e15163, qw= 0x9e3779b9
public RC5 (byte[] key) {
int c = (key.length +3)/4;
int[] L = new int[c];
for (int i=0; i< key.length; i++) {
L[i/4] = ((key[i] & 0xFF) << (8 * (i%4)));}

int t = 2*(r+1);
s = new int[t];
s[0] = pw;
for(int i=1; i<t; i++) {
   s[i] = s[i-1]+qw; }
```

```
int A=0; B=0, i=0, j=0;
int v = 3 * Math.max(c,t);
for(int s=0; s<v; s++){
A = S[i] = Integer.rotateLeft((S[i]+A+B),3);
B = L[j] = Integer.rotateLeft((L[i]+A+B),(A+B));
i = (i+1)%t;
j = (j+1)%t;
}
}

public int[] encrypt(int[] p){
int A = p[0]+S[0];
int B = p[1]+S[1];
for (int i=1; i<=r; i++){
A= Integer.rotateLeft(A^B,B)+S[2*i];
B = Integer.rotateLeft(B^A,A)+S[2*i+1];}

return new int[]{A,B};}

public int[] decrypt(int[] c){
int A = c[0];
int B = c[1];
for(i=r; i>=1; i--){
```

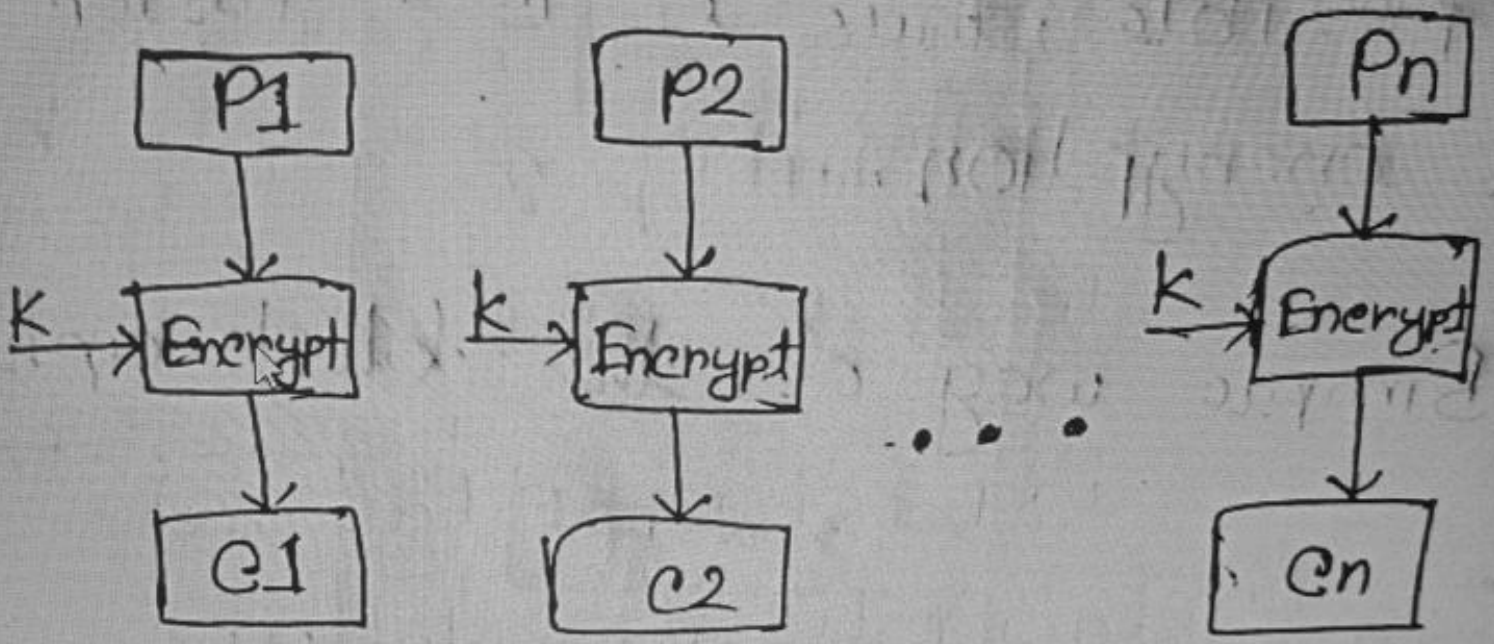
```
B = Integer.RotateRight(B-S[2*i+1], A)^A;
A= Integer.rotateRight(A-S[2*i],B)^B; }
A -= S[0];
B -= S[1];
return new int[]{A,B}; }
public static void main(String[] args) {
byte[] key = "MySecretKey12345".getBytes();
RC5 rc5 = new RC5(key);
int[] plaintext = {0x12345678, 0x9ABCDEF0};
System.out.printf("Plaintext: %08x %08x\n",
                  Plaintext[0], Plaintext[1]);
int[] ciphertext = rc5.encrypt(Plaintext);
System.out.printF("Encrypted: %008x %0 8 x\n
                  ciphertext[0], ciphertext[1]);
int[] decrypted = rc5.decrypt(ciphertext);
System.out.printf("Decrypted : %08x %008x\n",
                  decrypted[0], decrypted[1]); } }
```

Sample output:

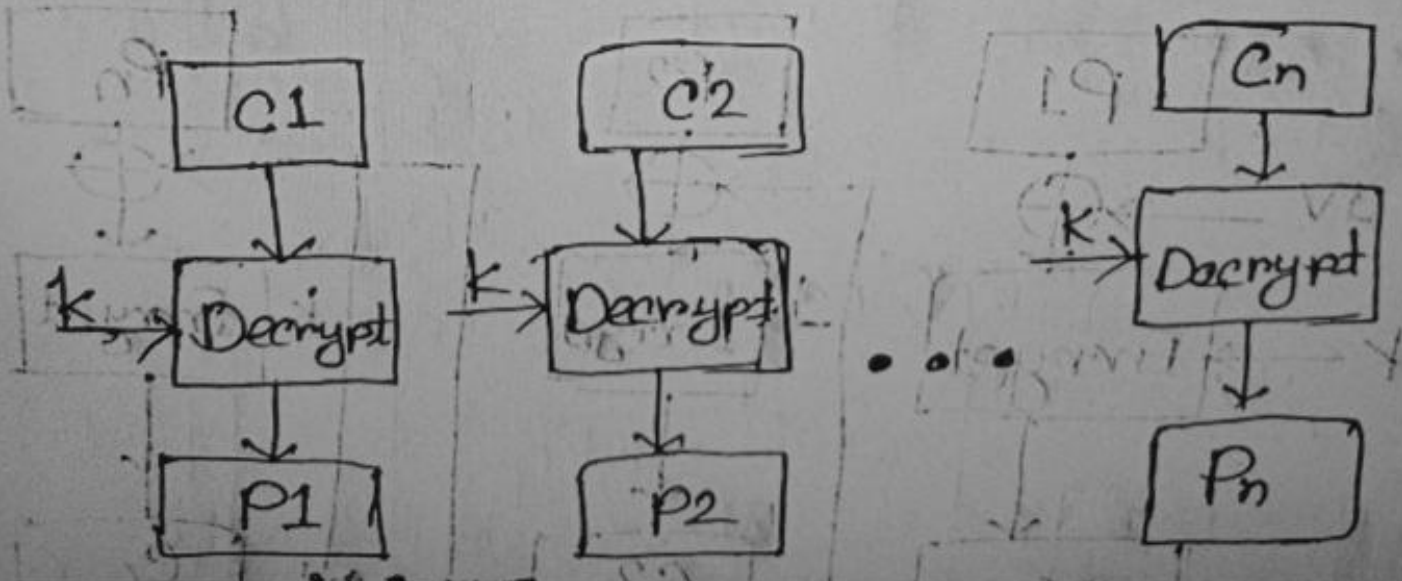
```
plaintext: 12345678 9ABCDEF0
Encrypted: E23456 5E91A7B9
Decrypted: 12345678 9ABCDEF0
```

e procedure of ECB is illustrated

## Encryption

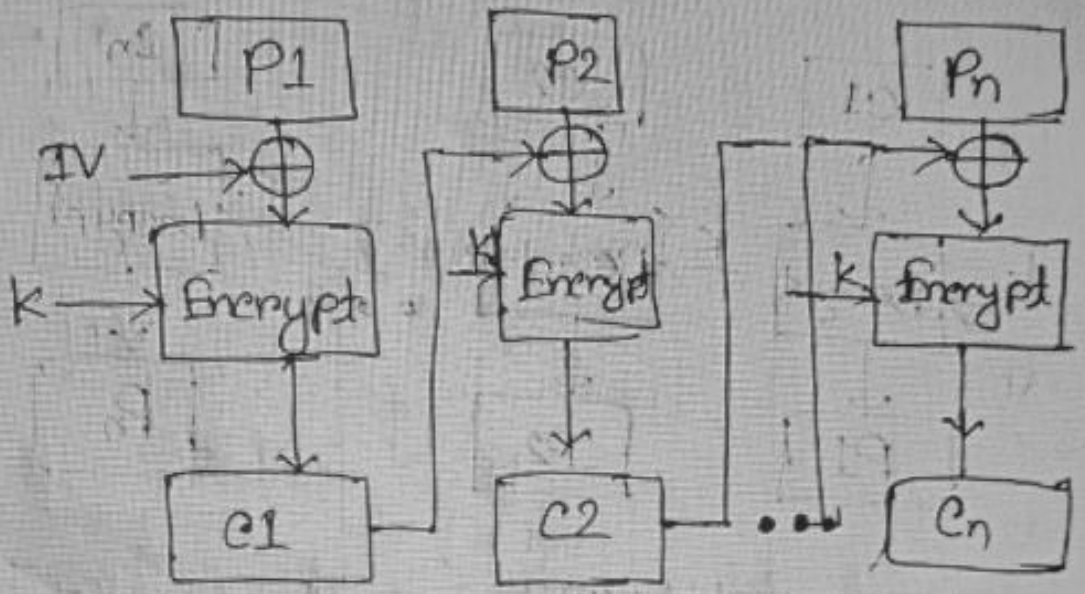



## Decryption



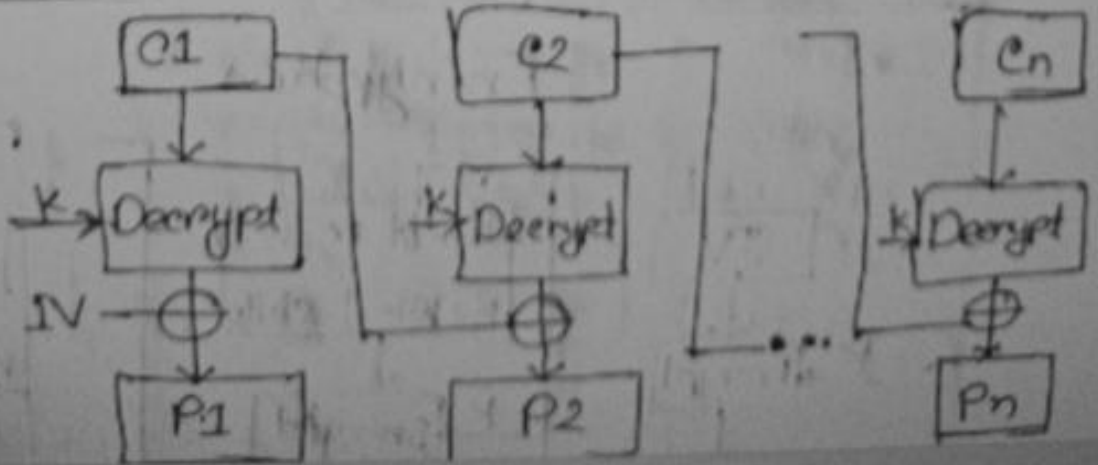
CBC Block Diagram :-

## Encryption



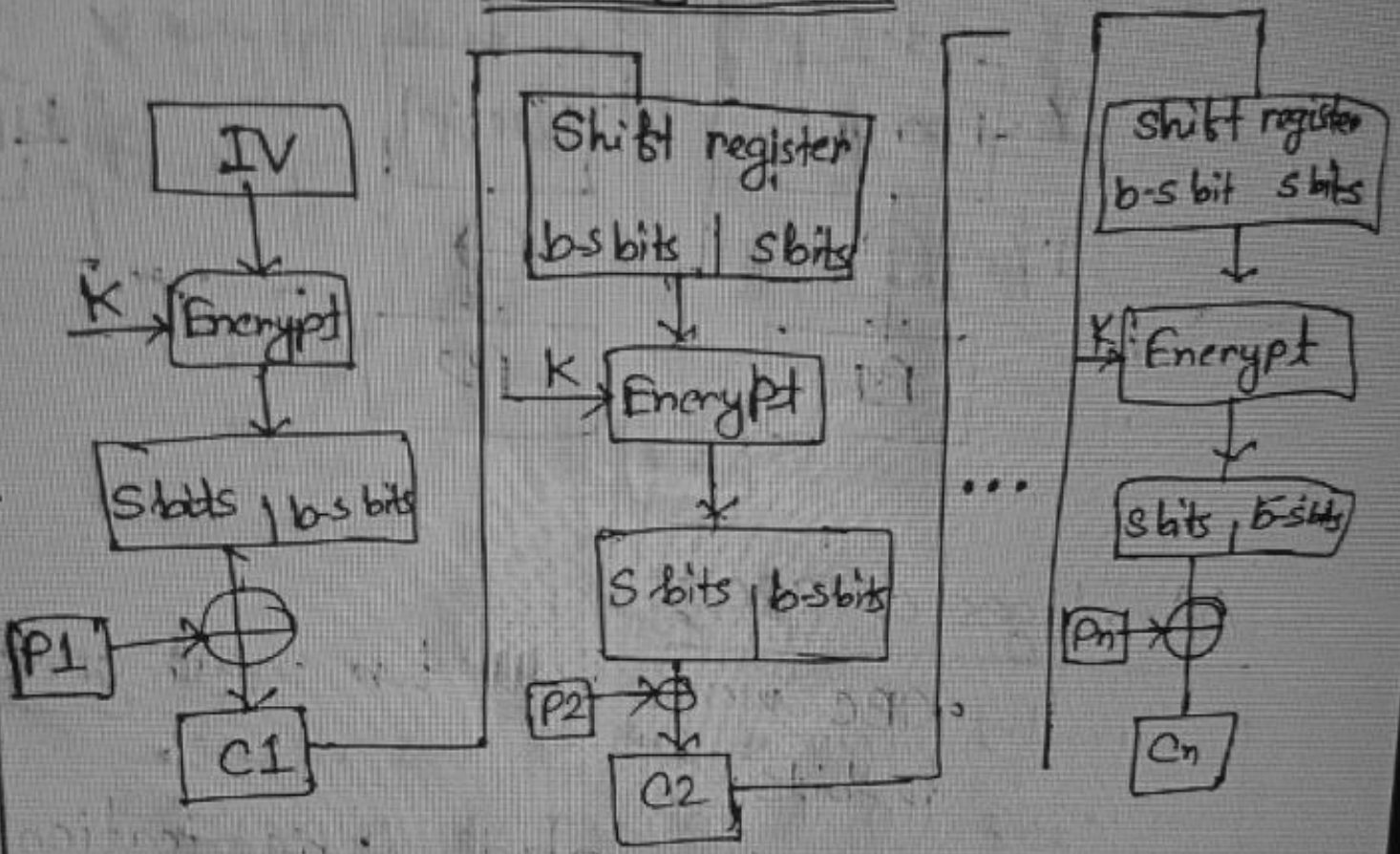



## Decryption :

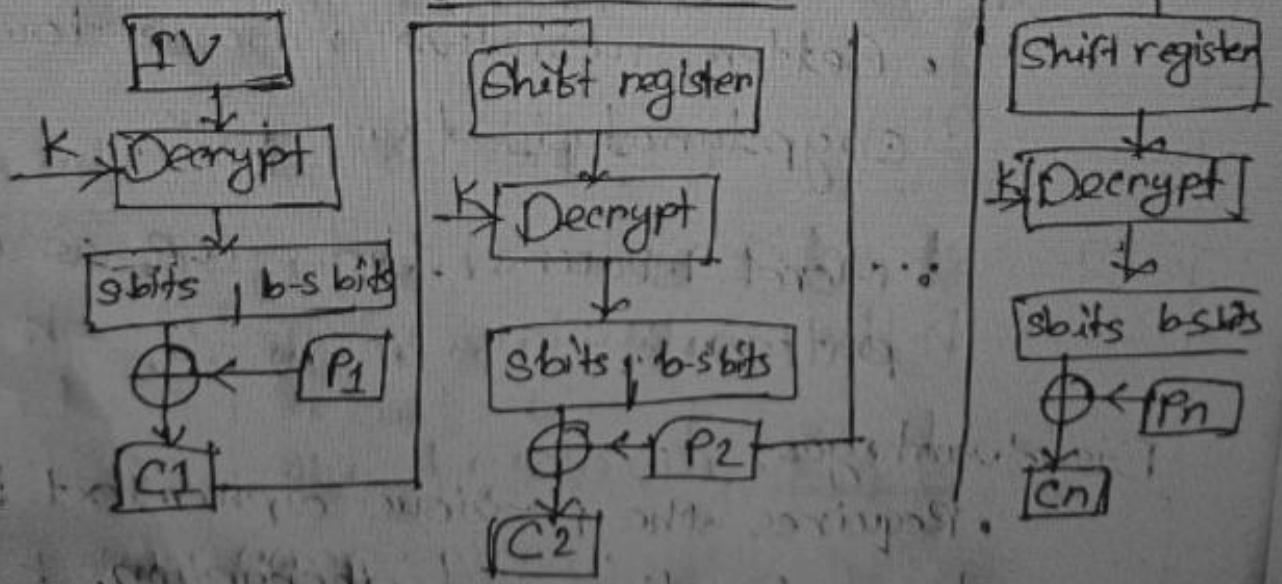


# CFB Block Diagram:

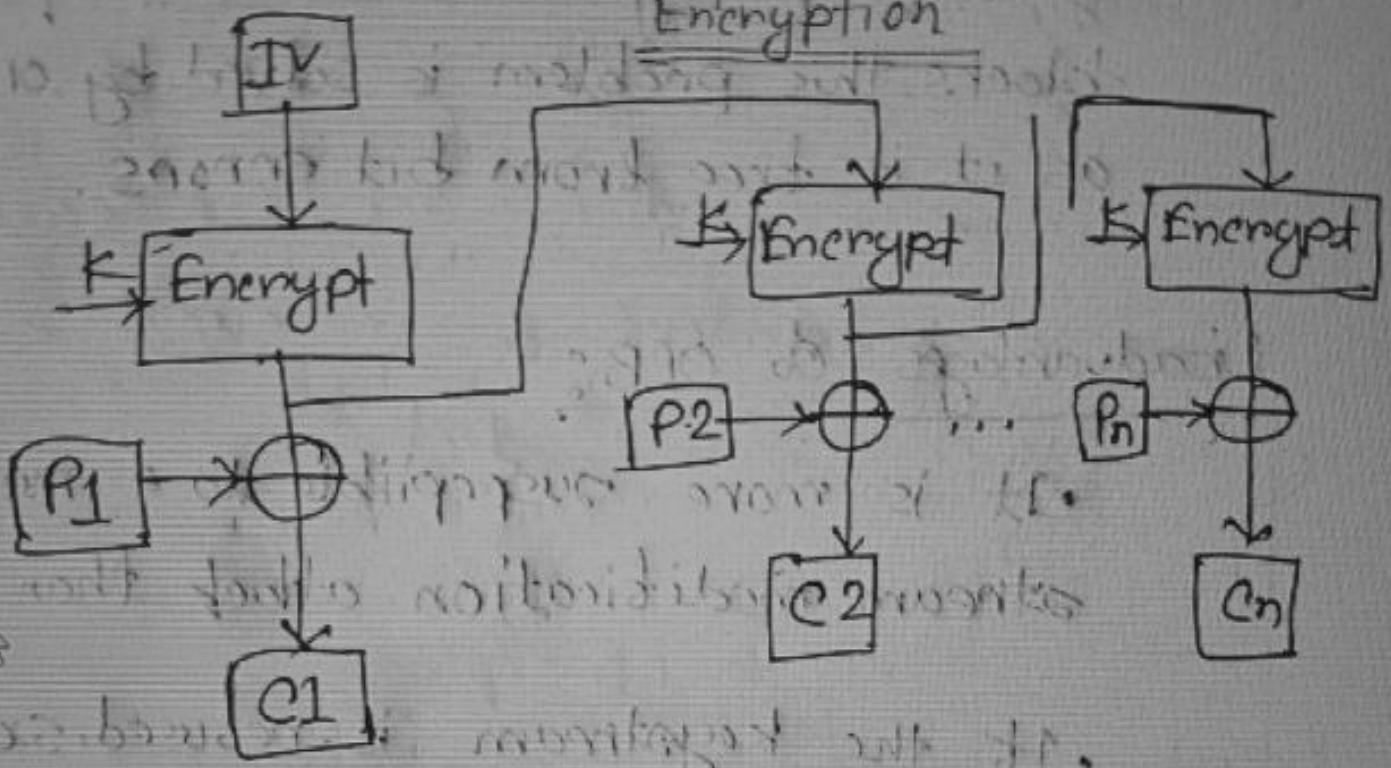
## Encryption.



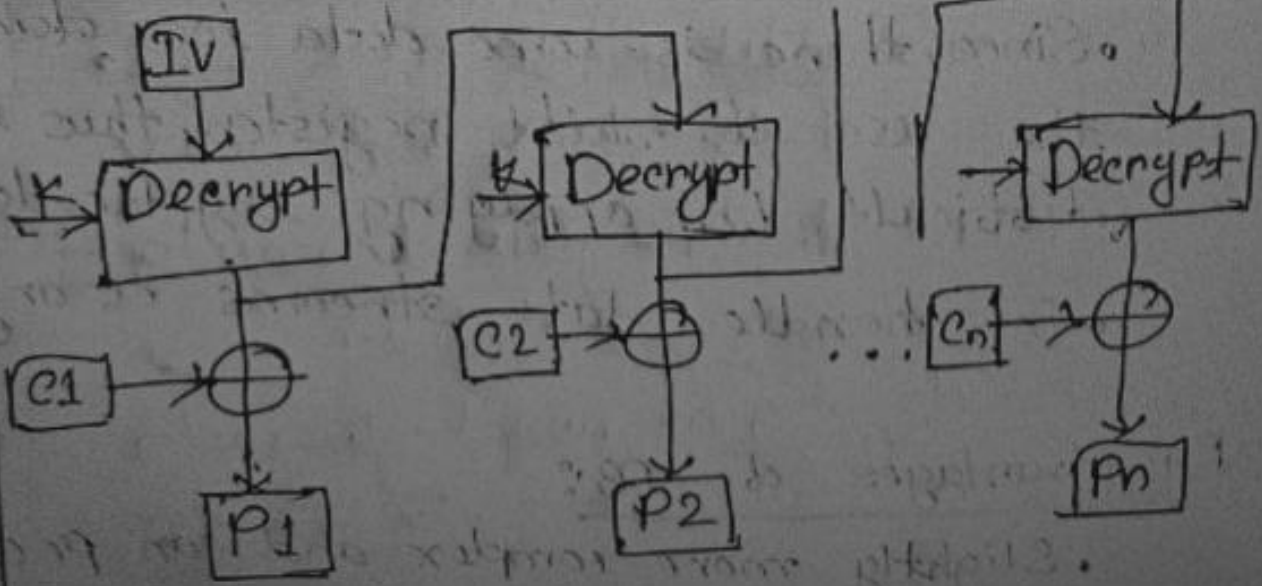

## Decryption



# OFB Block Diagram:

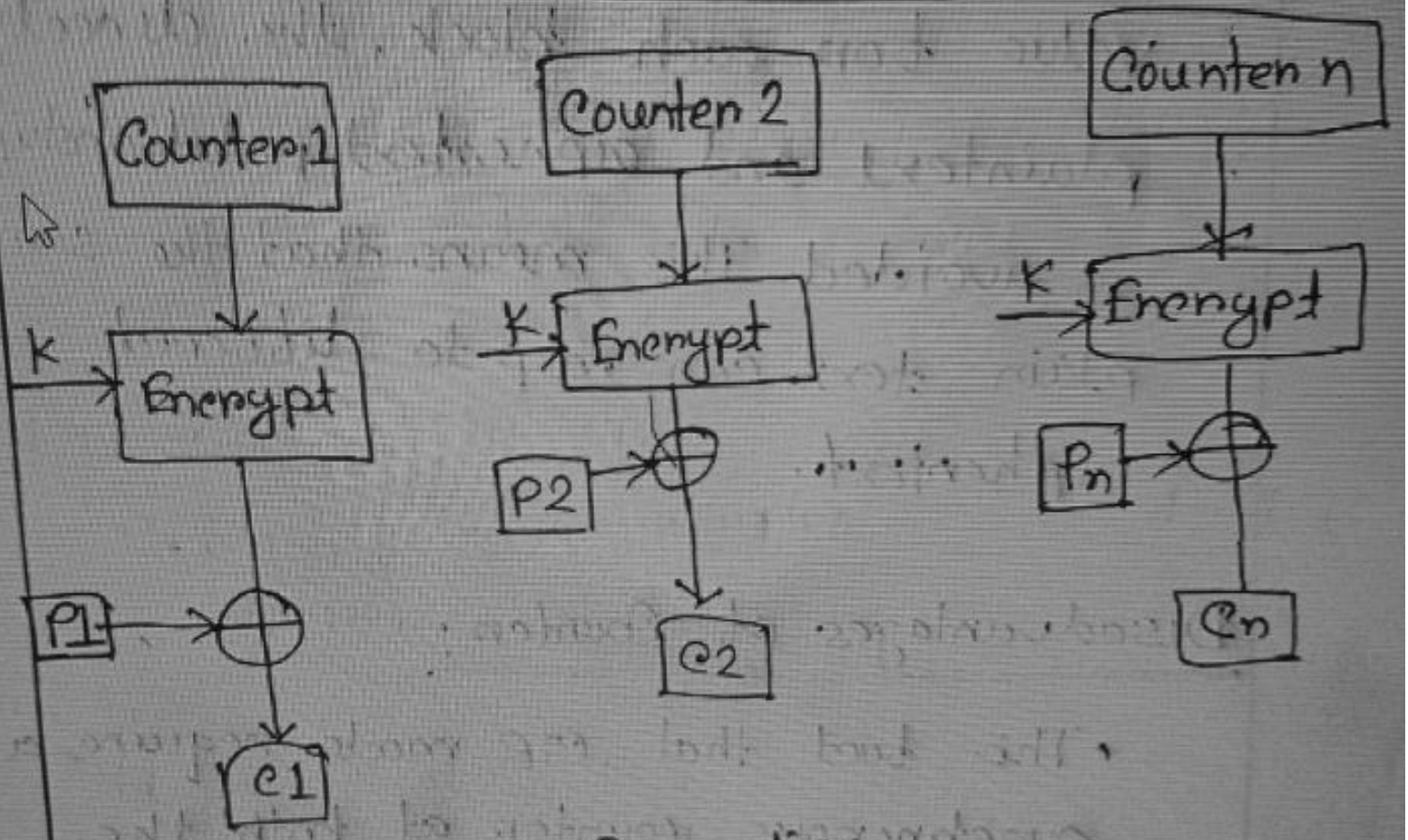




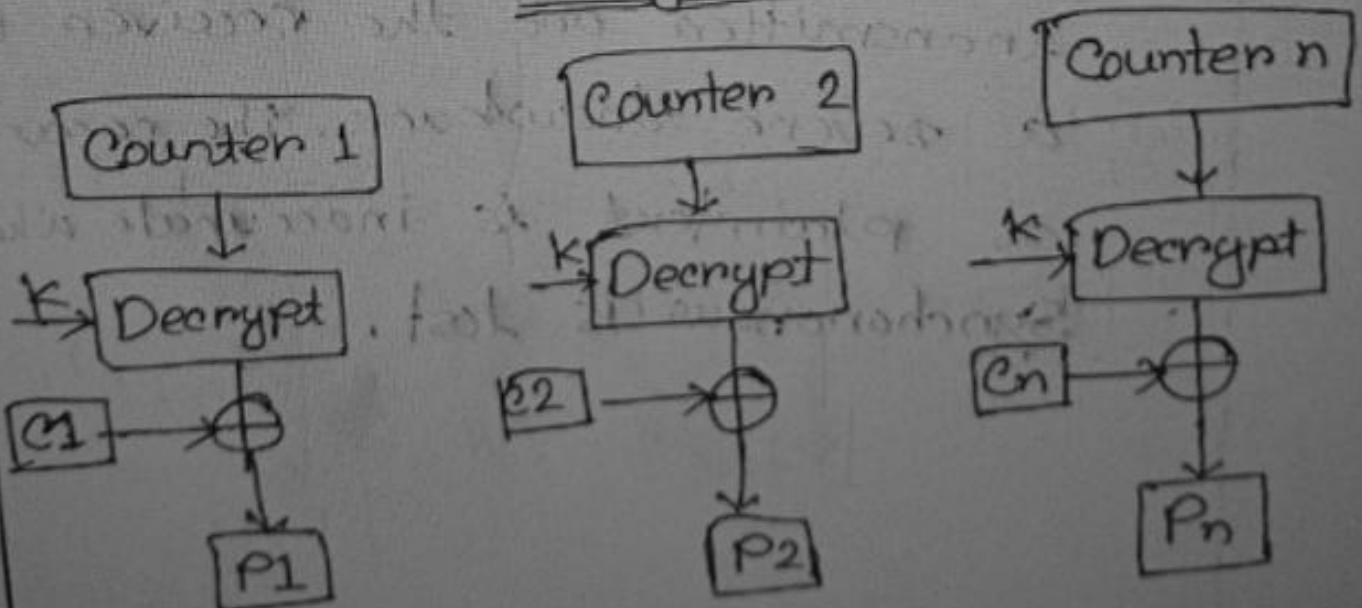



# Block Diagram of CTR:

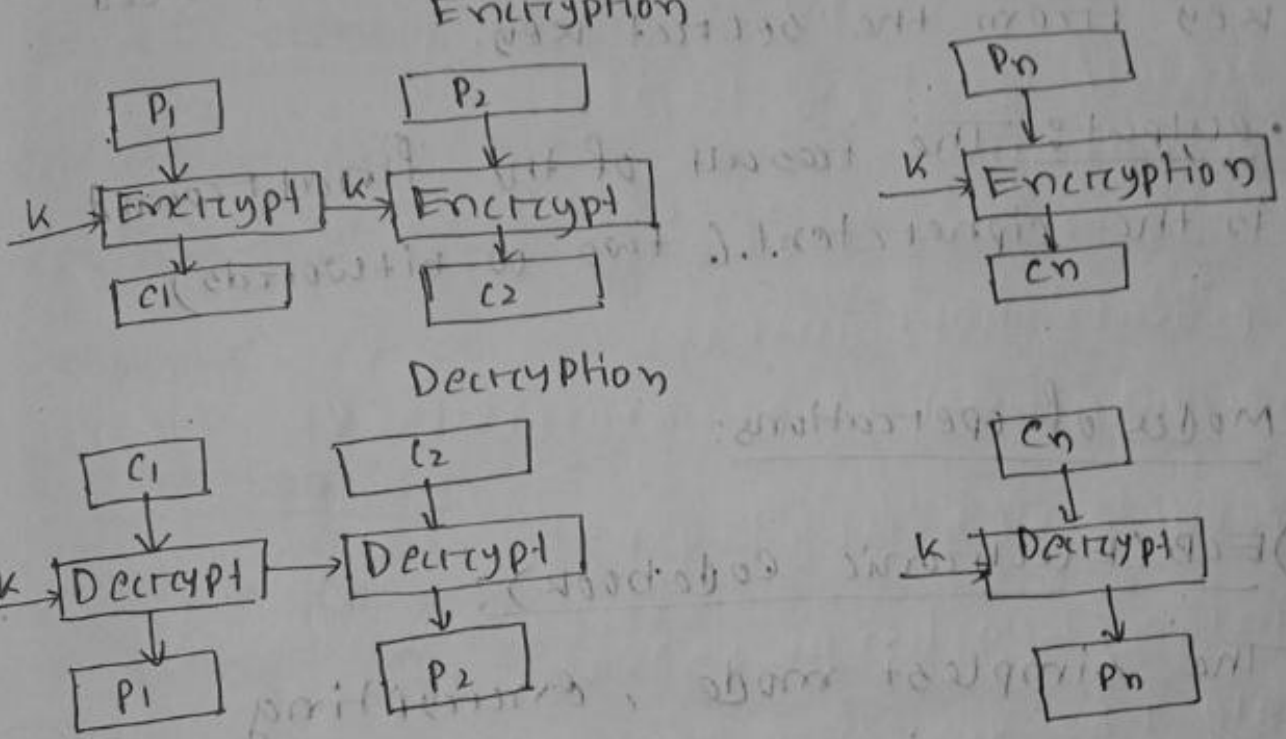
## Encryption




## Decryption



RC5 is a symmetric block cipher known for its simplicity and flexibility in key and block sizes.




## RC5 Block Diagram:

- **Input:** The plaintext is divided into two words (w bits each)
- **Initial Key Addition:** The input words are combined with a portion of the expanded key

- Mixing (circular-shift): These operations (XOR and Rotations) are applied iteratively in multiple rounds.
- Key schedule: Generates the expanded key from the secret key.
- Output: The result of the final round is the ciphertext (two 32-bit words).

Modes of operations:

i) ECB (Electronic Codebook):

The simplest mode, encrypting each block independently, suitable for short, random data but can reveal patterns in non-random

ii) CBC (Cipher Block chaining):

Each block is XORed with the previous ciphertext block before encryption. providing better security than ECB

iii) OFB (output Feedback):

Uses the previous ciphertext block to generate the keystream, making it suitable for noisy channel.

iv) CFB (cipher feedback):

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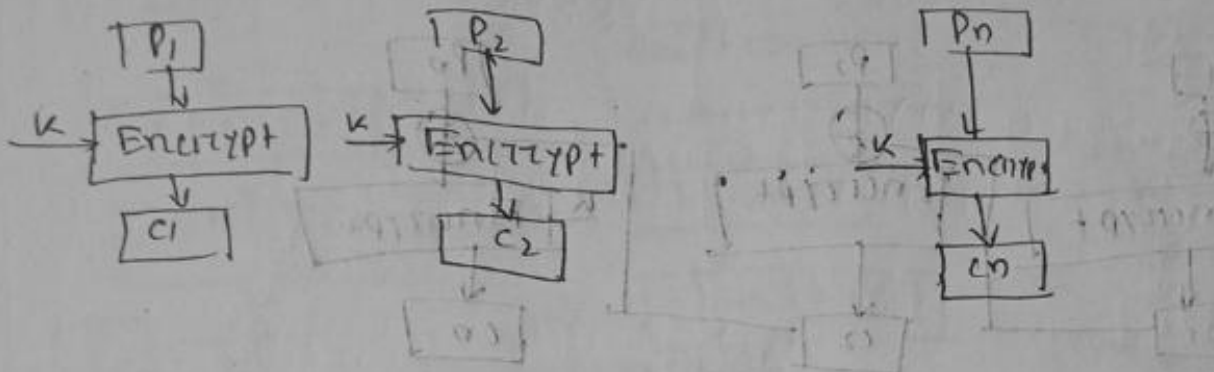
v) Counter (CTR):

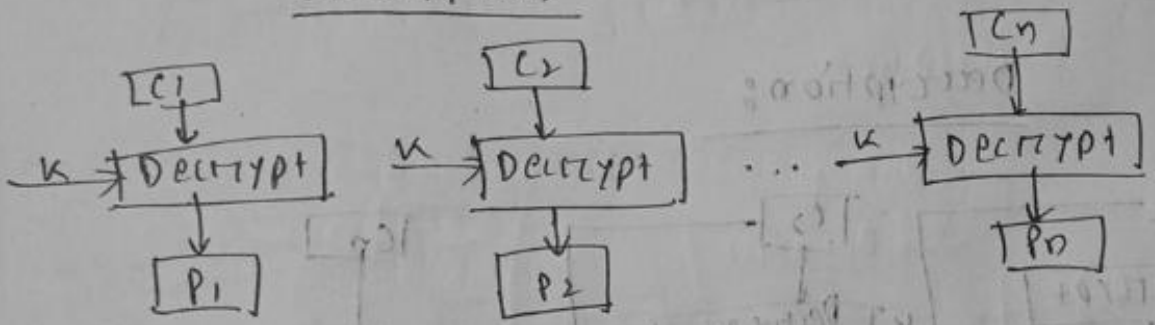
Uses a counter to generate the keystream allowing for parallel encryption and decryption.

## ECB

### Encryption




### Decryption




### Advantages of ECB:

→ Parallel encryption of blocks of bits is possible thus it is a faster way of encryption.

→ simple way of the block cipher.

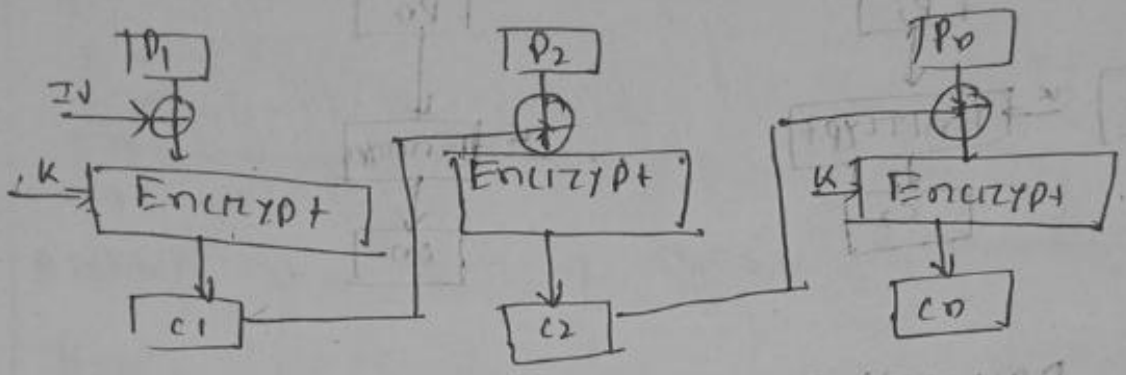
### Disadvantages of ECB:

→ Prone to encryption of blocks of bits is possible

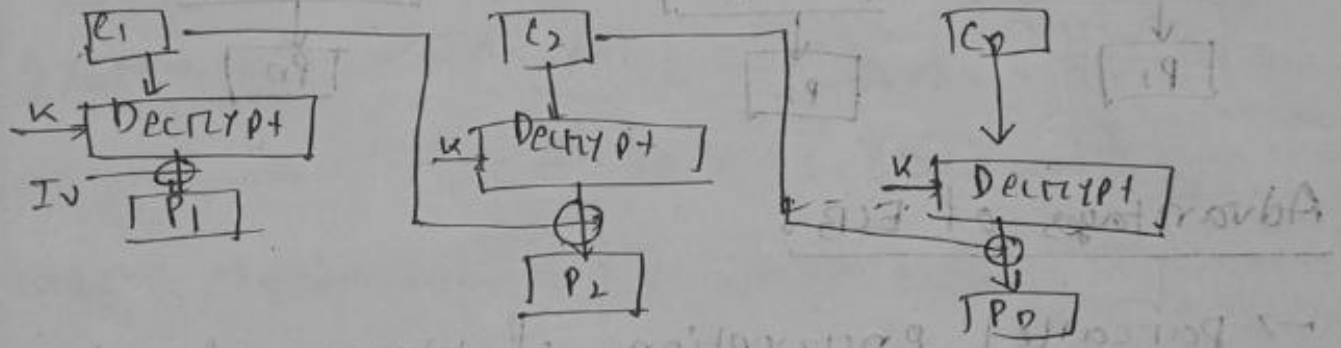
→ simple ways of the block cipher

# CBC

## Encryption




## Decryption:




## advantages:

→ CBC works well for input greater than b bits.

→ CBC is a good athentication mechanism

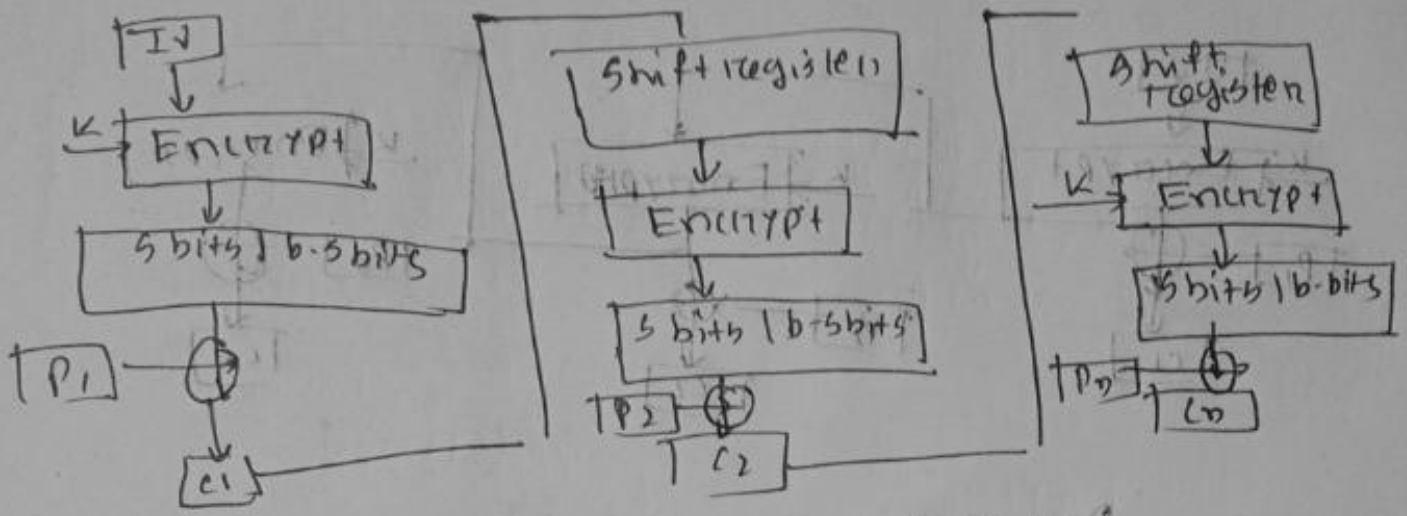
→ Better resistive nature towards encryptalysis than ECB.

## Disadvantages:

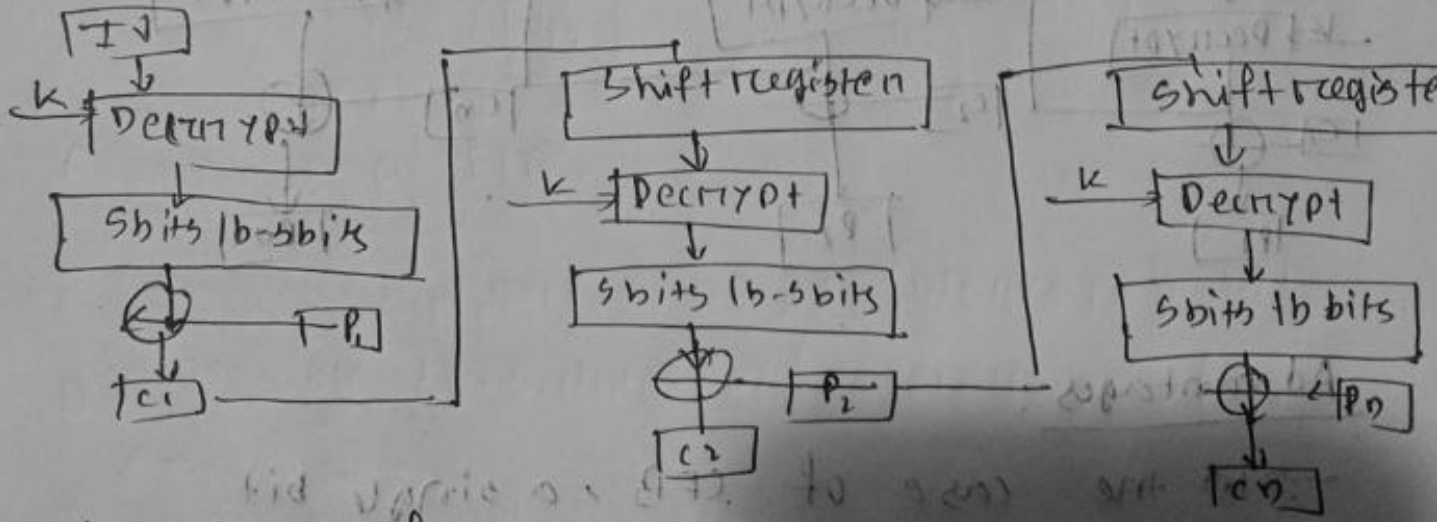
→ Requires the previous ciphertext boor for encryption and decryption.

# CFB

## Encryption




## Decryption




## advantages of CFB :

→ there is some data loss due to the use of shift registers, thus it is difficult for applying cryptanalysis

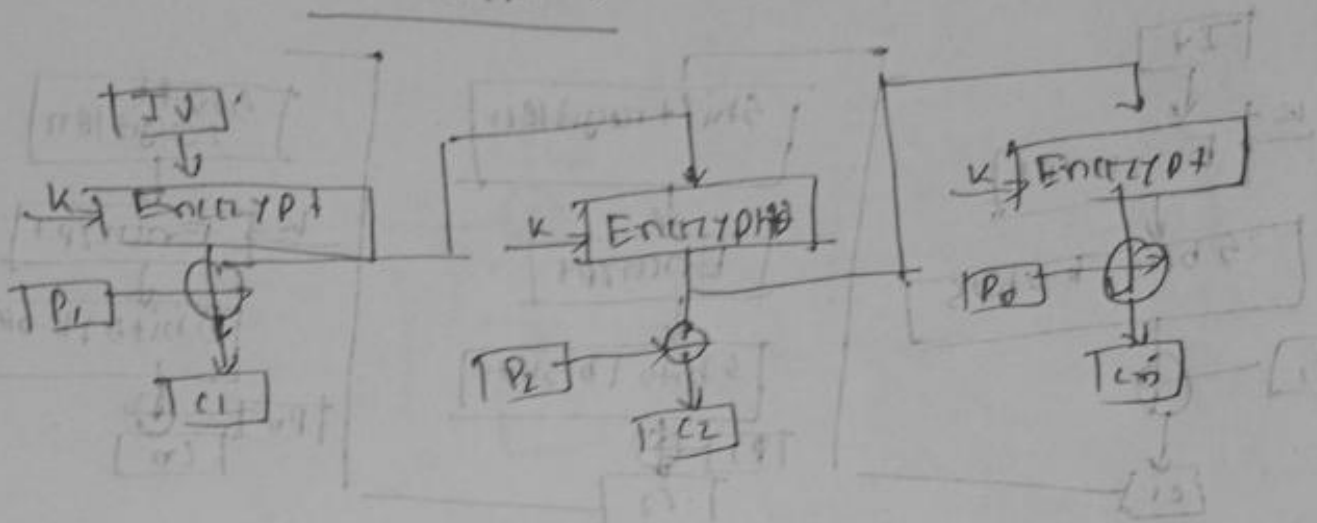
→ can handle data ~~streams~~ of any size

## Disadvantages:

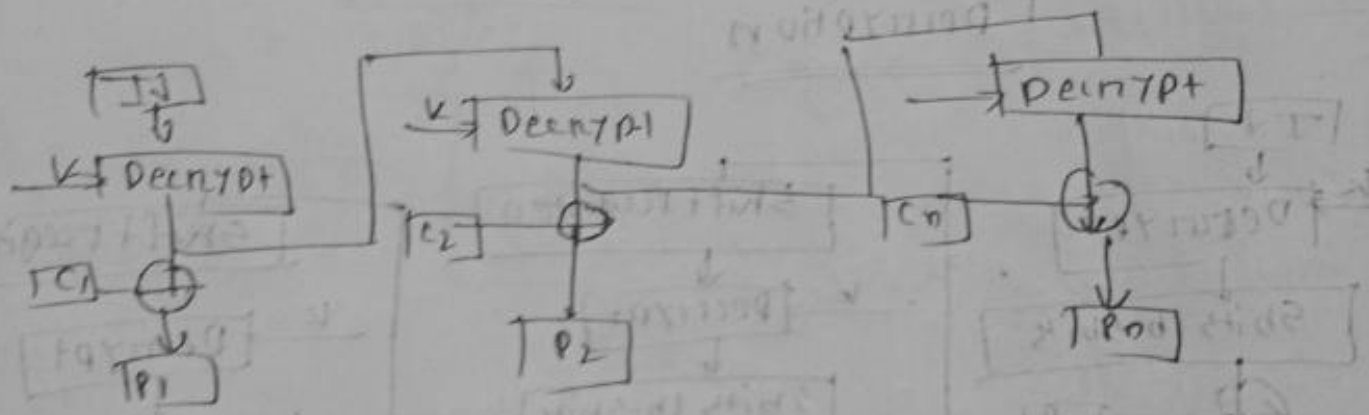
→ slightly more complex and can propagate errors

# OFB

## Encryption




## Decryption




**Advantages:**

→ In the case of CFB, a single bit error in a block is propagated to all subsequent blocks. This problem is solved by OFB as it is free from bit errors.

**Disadvantages:**

→ It is more susceptible to a message stream modification attack than CFB.

## Java implementation of RC5:

```
import java.nio.ByteBuffer;
import java.util.Arrays;

public class RC5 {
private final int w= 32;
private final int r= 12;
private final int b = 16;
private final int[] s;
private final int pw = 0xb7e15163, qw= 0x9e3779b9

public RC5 (byte[] key) {
int c = (key.length +3)/4;
int[] L = new int[c];

for (int i=0; i< key.length; i++) {
L[i/4] = ((key[i] & 0xFF) << (8 * (i%4)));}

int t = 2*(r+1);
s = new int[t];
s[0] = pw;
for (int i=1; i<t; i++) {
   s[i] = s[i-1] + qw; }
```

```
int A=0; B=0, i=0, j=0;
int v = 3 * Math.max(c,t);
for(int s=0; s<v; s++){
A = S[i] = Integer.rotateLeft((S[i]+A+B),3);
B = L[j] = Integer.rotateLeft((L[i]+A+B),(A+B));
i = (i+1)%t;
j = (j+1)%t;
}
}

public int[] encrypt(int[] pt){
int A = pt[0]+S[0];
int B = pt[1]+S[1];
for (int i=1; i<=r; i++){
A= Integer.rotateLeft(A^B,B)+S[2*i];
B = Integer.rotateLeft(B^A,A)+S[2*i+1];}
return new int[]{A,B};}

public int[] decrypt(int[] ct){
int A = ct[0];
int B = ct[1];
for(i=r; i>=1; i--){
```

```
B = Integer.RotateRight(B-S[2*i+1], A)^A;
A= Integer.rotateRight(A-S[2*i], B)^B; }
A -= S[0];
B -= S[1];
return new int[]{A,B}; }
public static void main(String[] args) {
byte[] key = "MySecretKey12345".getBytes();
RC5 rc5 = new RC5(key);
int[] plaintext = {0x12345678, 0x9ABCDEF0};
System.out.printf("Plaintext: %08x %08x\n",
                  plaintext[0], plaintext[1]);
int[] ciphertext = rc5.encrypt(plaintext);
System.out.printf("Encrypted: %08x %08x
                  ciphertext[0], ciphertext[1]);
int[] decrypted = rc5.decrypt(ciphertext);
System.out.printf("Decrypted: %08x %08x\n",
                  decrypted[0], decrypted[1]); } }
```

Sample output:

```
Plaintext: 12345678 9ABCDEF0
Encrypted: E2C3456 5E91A7B9
Decrypted: 12345678 9ABCDEF0
```