Solving a fixed-key challenge without the key

or – how to padding oracle

malet ∧ crave

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Given Description

```
Howdy, howdy...
nc 206.189.92.209 12345
[Attachments]
```

The Challenge (Encryption)

```
nc 206.189.92.209 12345

Welcome to our super secure enc/dec server.
We use hmac, so, plz don't hack us (and you can't). Thanks.
Choose one:
1. encrypt data
2. decrypt data
3. quit
1
prefix: hello
suffix: world
41d032627e632e3a9daad7e6b3001e593e5c573cc [ ...MORE BYTES ]
```

The Challenge (Decryption)

```
Choose one:
1. encrypt data
2. decrypt data
3. quit
2
data: 41d032627e632e3a9daad7e6b3001e593e5c573cc [ ...MORE BYTES]
OK
```

A First Look

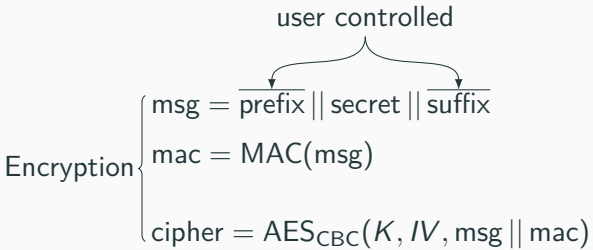
```
encrypt_key = '\xff' * 32
secret = 'MeePwnCTF{#flag_here#}'
hmac_secret = ''
blocksize = 16
hmac_size = 20
```

"*Don't look at the fixed key, it is not a fixed key challenge*" said someone.
And we listened to them...

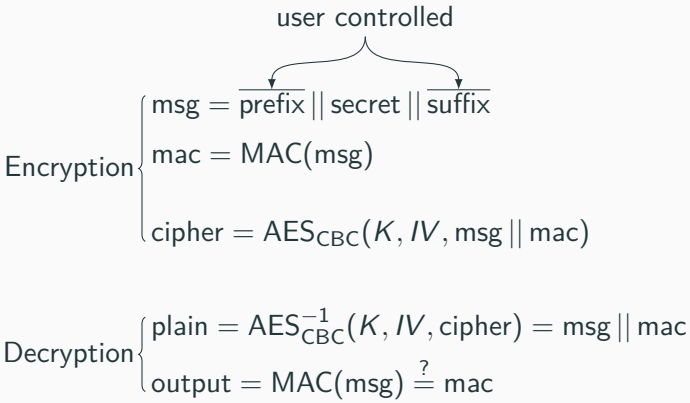
What we know by now

- The start of the flag
- The block and key sizes

An Abstract View



An Abstract View



What we know by now

- The start of the flag
- The block and key sizes
- CBC Mode
- Weird MAC construction
- Mac-then-Encrypt

Cipher Block Chaining – encryption

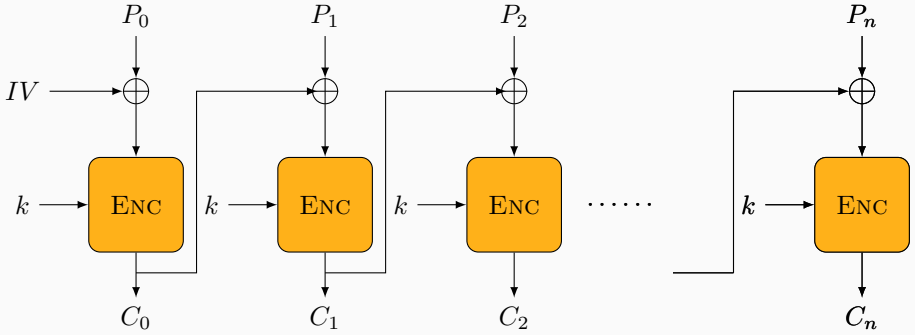


Figure 1: CBC encryption

Cipher Block Chaining – decryption

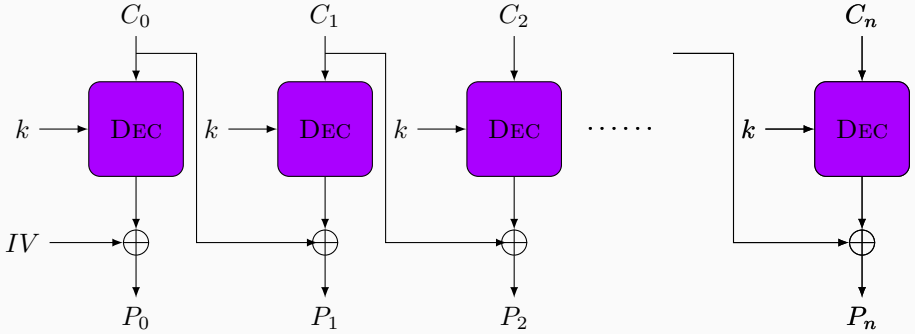
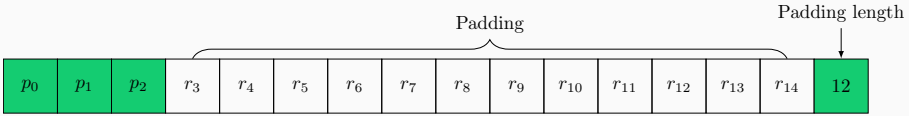
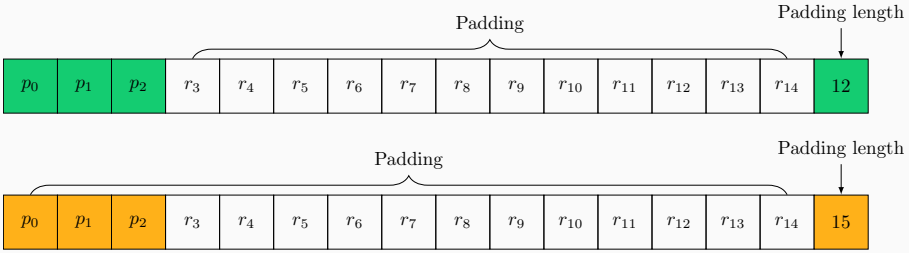


Figure 2: CBC decryption

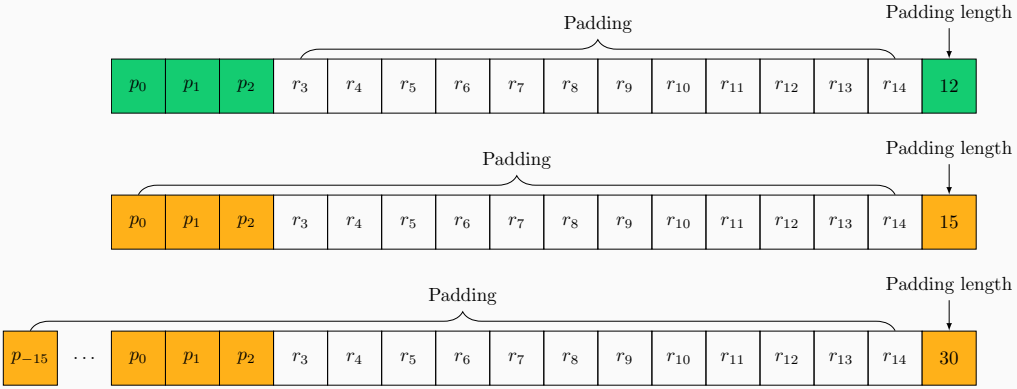
Padding


Padding
Padding length
p_0
p_1
p_2
r_3
r_4
r_5
r_6
r_7
r_8
r_9
r_{10}
r_{11}
r_{12}
r_{13}
r_{14}
12

Padding


Padding
Padding length
p_0 p_1 p_2 r_3 r_4 r_5 r_6 r_7 r_8 r_9 r_{10} r_{11} r_{12} r_{13} r_{14} 12
Padding
Padding length
p_0 p_1 p_2 r_3 r_4 r_5 r_6 r_7 r_8 r_9 r_{10} r_{11} r_{12} r_{13} r_{14} 15

Padding

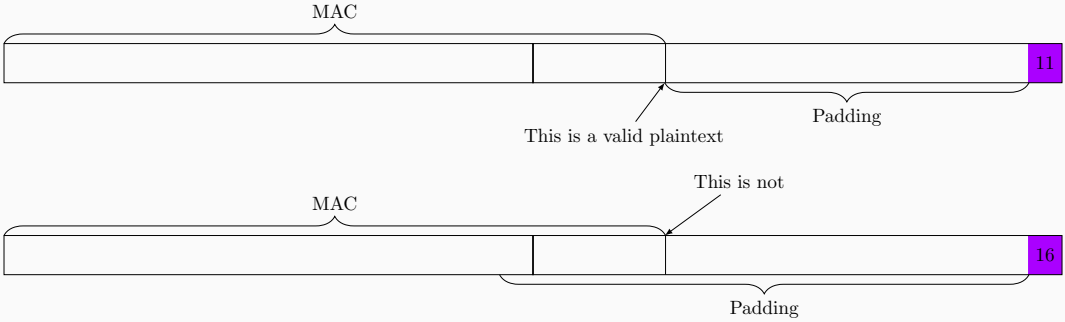

Padding
Padding length
p_0 p_1 p_2 r_3 r_4 r_5 r_6 r_7 r_8 r_9 r_{10} r_{11} r_{12} r_{13} r_{14} 12
Padding
Padding length
p_0 p_1 p_2 r_3 r_4 r_5 r_6 r_7 r_8 r_9 r_{10} r_{11} r_{12} r_{13} r_{14} 15
Padding
Padding length
p_{-15} ... p_0 p_1 p_2 r_3 r_4 r_5 r_6 r_7 r_8 r_9 r_{10} r_{11} r_{12} r_{13} r_{14} 30

A Second Look

```
data = _aes.decrypt(data[blocksize:])
data = unpad(data)
plaintext = data[:-hmac_size]
mac = data[-hmac_size:]
computed = compute_hmac(plaintext)
if mac == computed:
    return True
else:
    return False
```

This looks like an oracle

A Padding Oracle



What we know by now

- The start of the flag
- The block and key sizes
- CBC Mode
- Weird MAC construction
- Mac-then-Encrypt
- Padding Oracle

Attack preliminaries

1. Compute the empty MAC blocks (there is no key)
2. Get the encrypted padded MAC blocks
3. Get the Schrottblock
4. Get the target block

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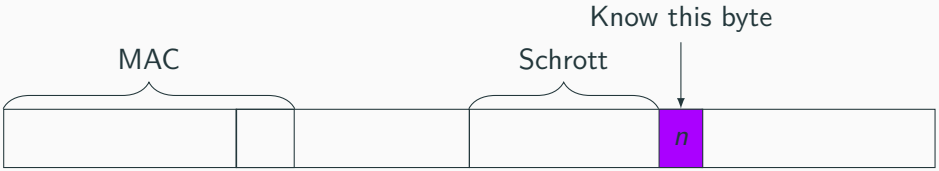
Attack explained



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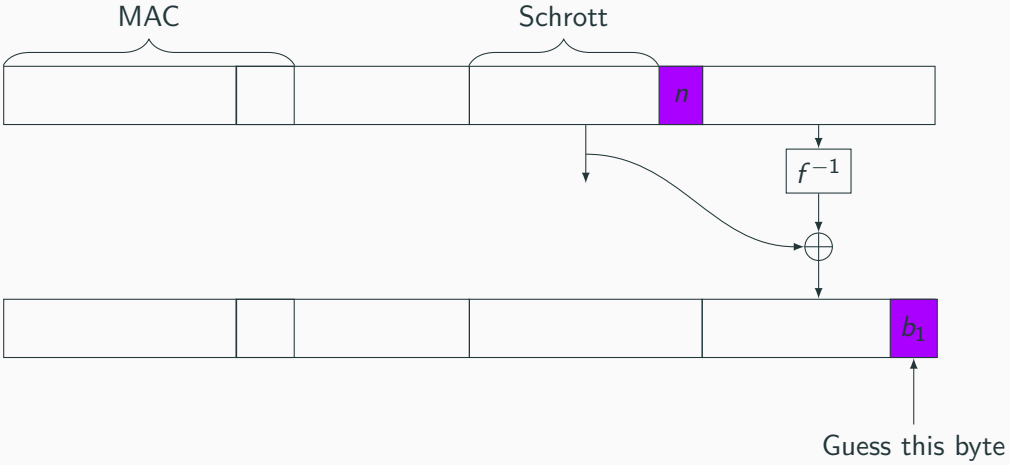

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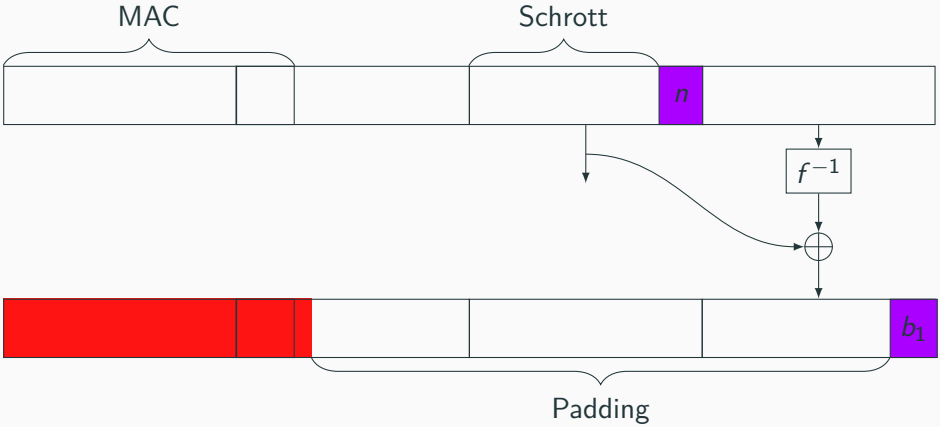

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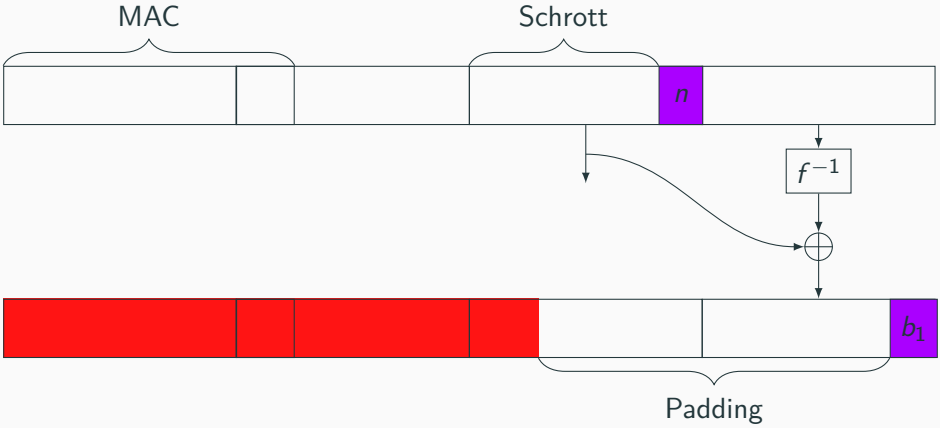

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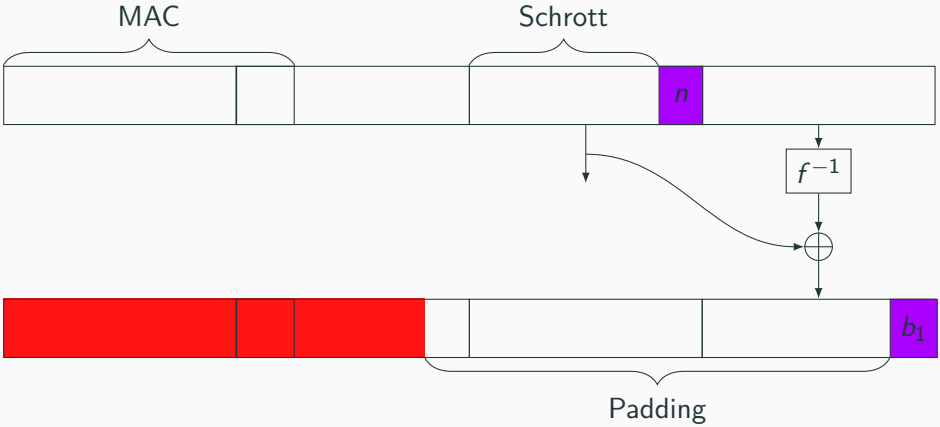

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