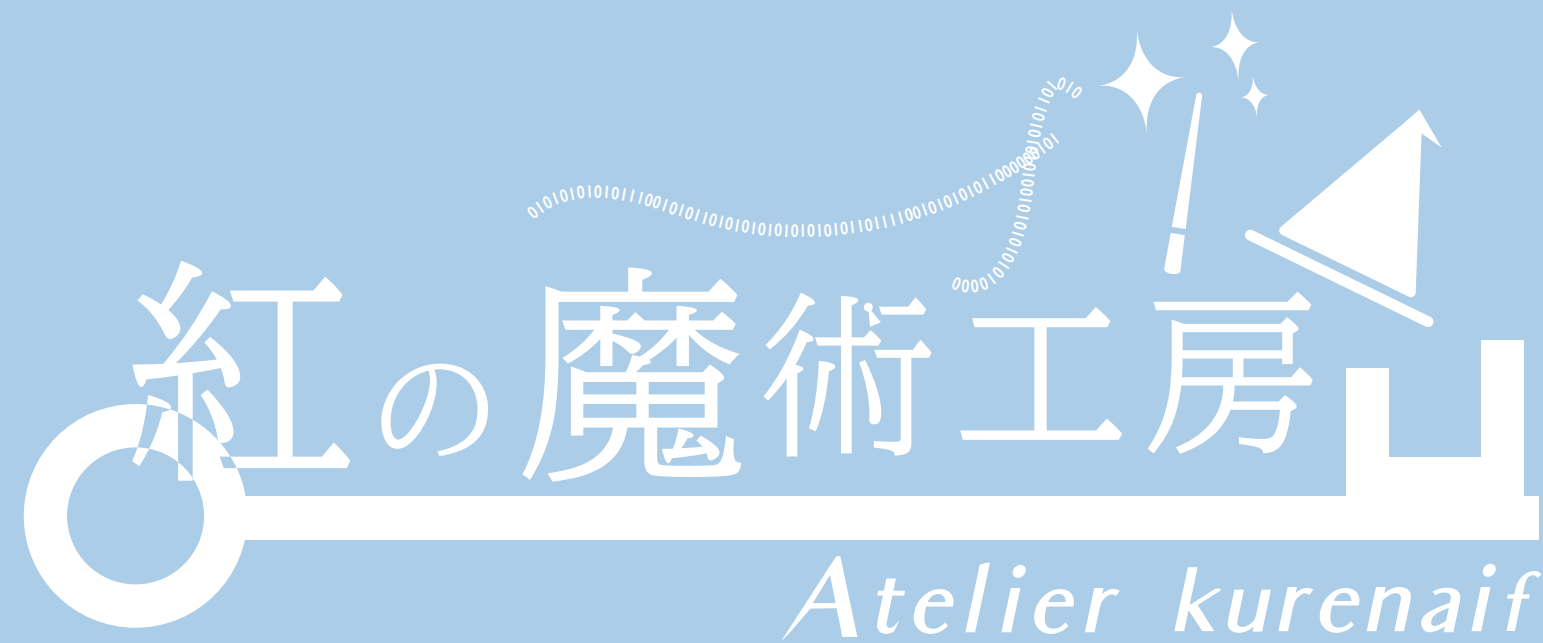


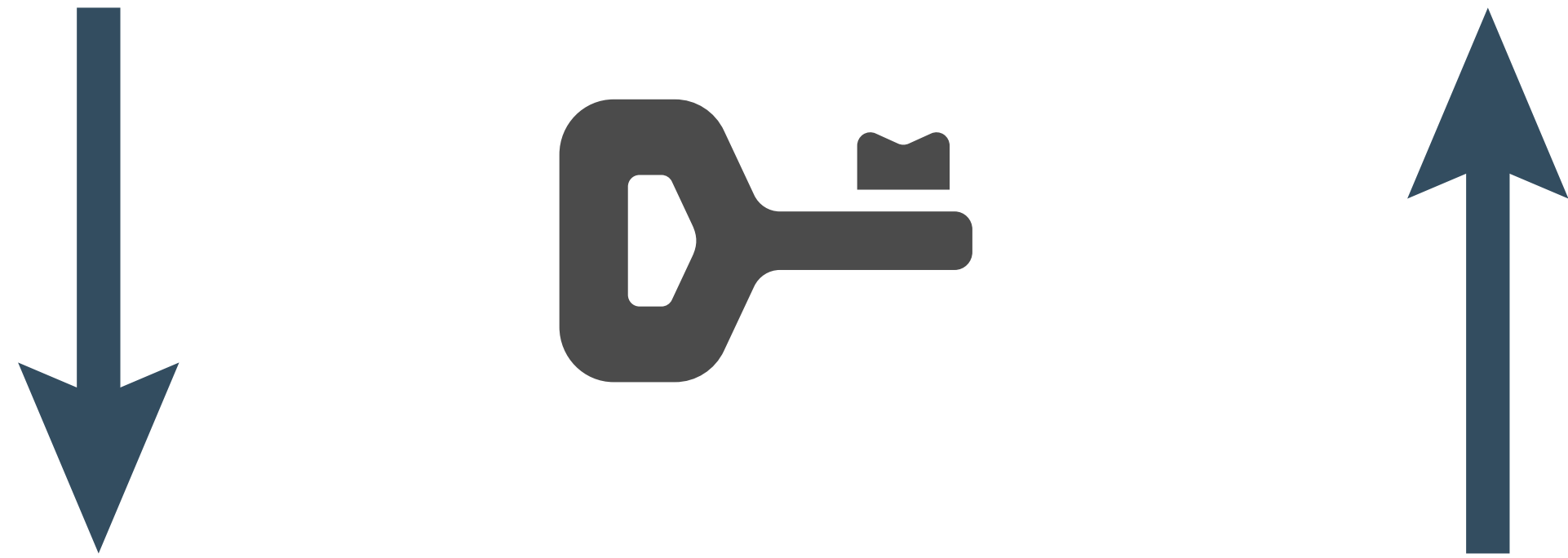
# CBC Padding Oracle Attack



Today's Topic

# Block Cipher (CBC)

long plain text(256bytes)



long cipher text(256 bytes)

What's Block Cipher?

long plain text(256bytes)



- \* fast
- \* same key
- \* safety



long cipher text(256 bytes)

What's Block Cipher?

long plain text(256bytes)

AES

long cipher text(256 bytes)

What's Block Cipher?

long plain text(256 bytes)

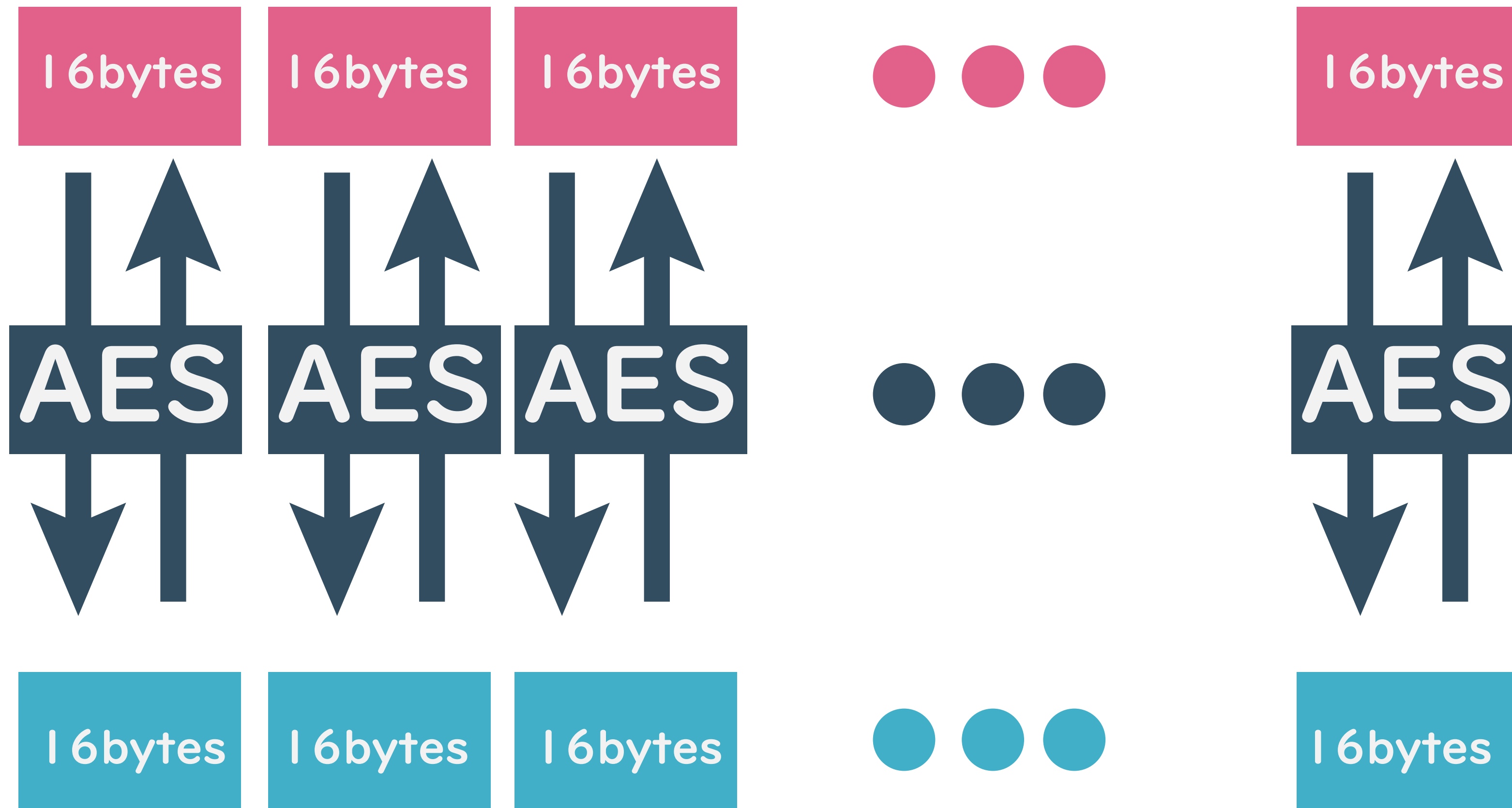
Sorry!  
Only 16 bytes can be encrypted!

AES

long cipher text(256 bytes)

What's Block Cipher?

plaintext

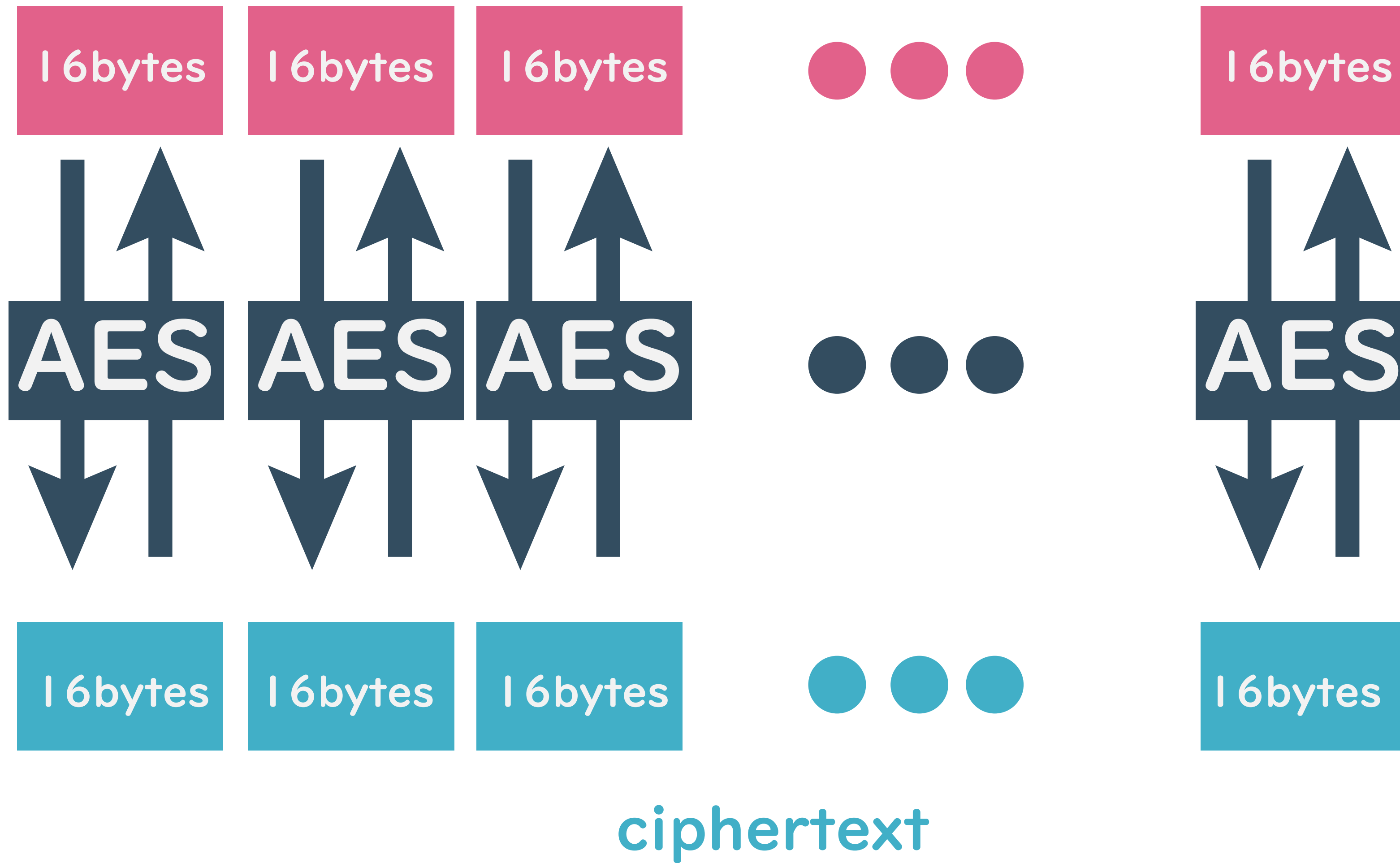


ciphertext

What's Block Cipher?



plaintext



This Algorithm Called  
AES-ECB

What's Block Cipher?



AES is Very Strong.

But, ECB is Very Weak

Alice

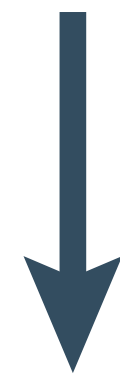
send

100\$

to Bob



Mallory (Mallory in The Middle)



Server

Why is the ECB so weak?

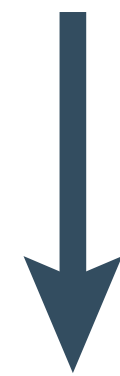
Alice



rewrite to “send 10000\$ to Marroly”



Mallory (Mallory in The Middle)



Server

Why is the ECB so weak?

Alice

send

100\$

to Bob

Mallory (Mallory in The Middle)

plain text

send

10000\$

to Mallory

cipher text

send

10000\$

to Mallory

Server

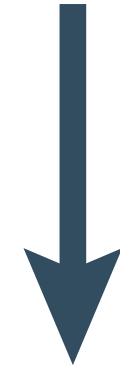
Why is the ECB so weak?

Alice

send

100\$

to Bob



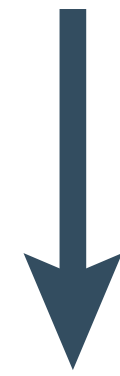
cipher text

send

10000\$

to Mallory

Mallory (Mallory in The Middle)



Server

Why is the ECB so weak?

Alice



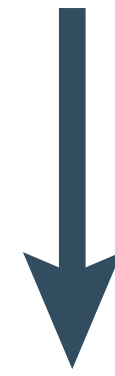
Mallory (Mallory in The Middle)



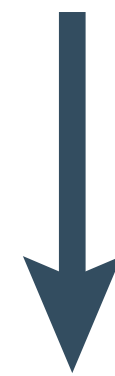
Server

Why is the ECB so weak?

Alice



Mallory (Mallory in The Middle)



Server

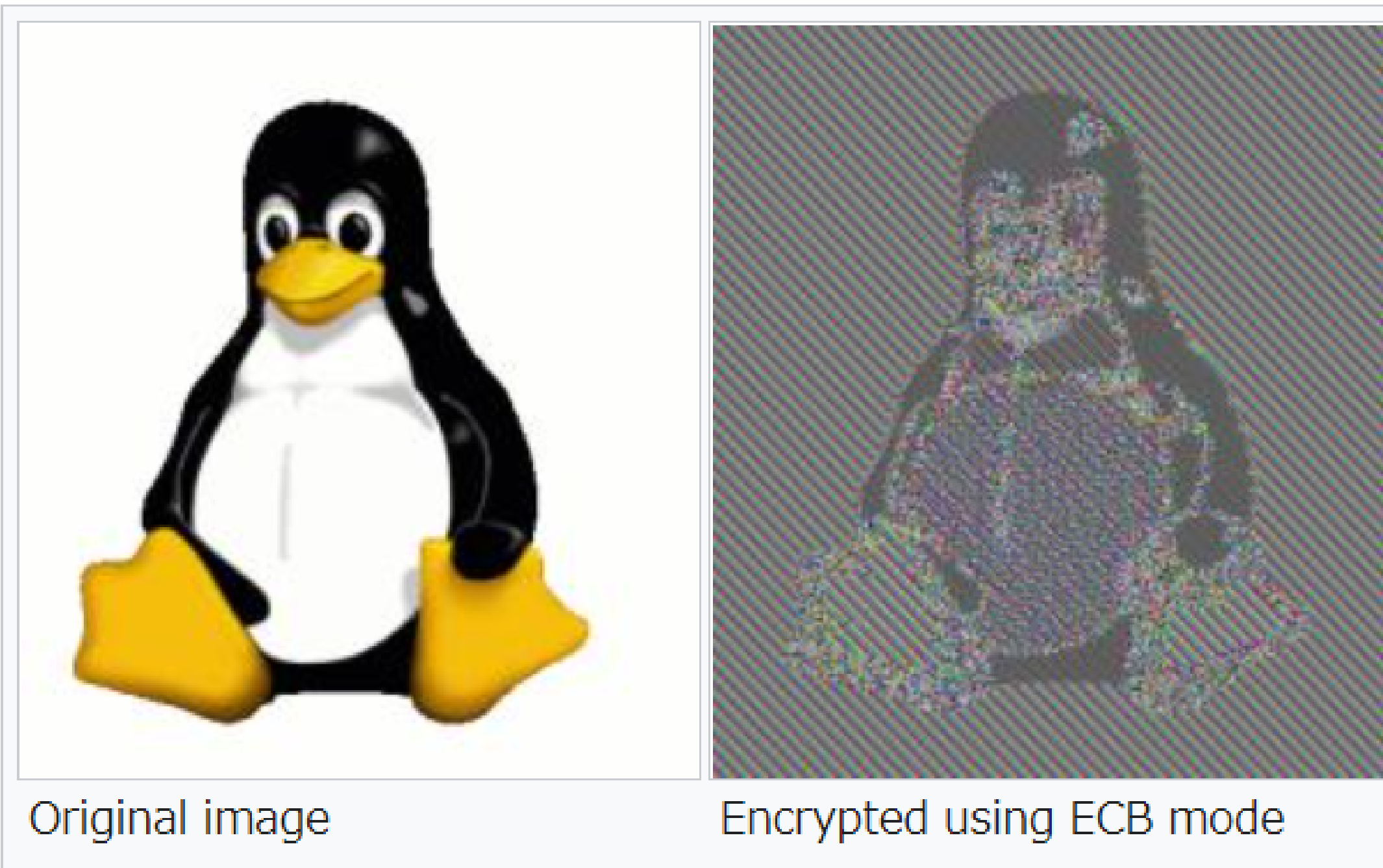


easy to falsification

Why is the ECB so weak?

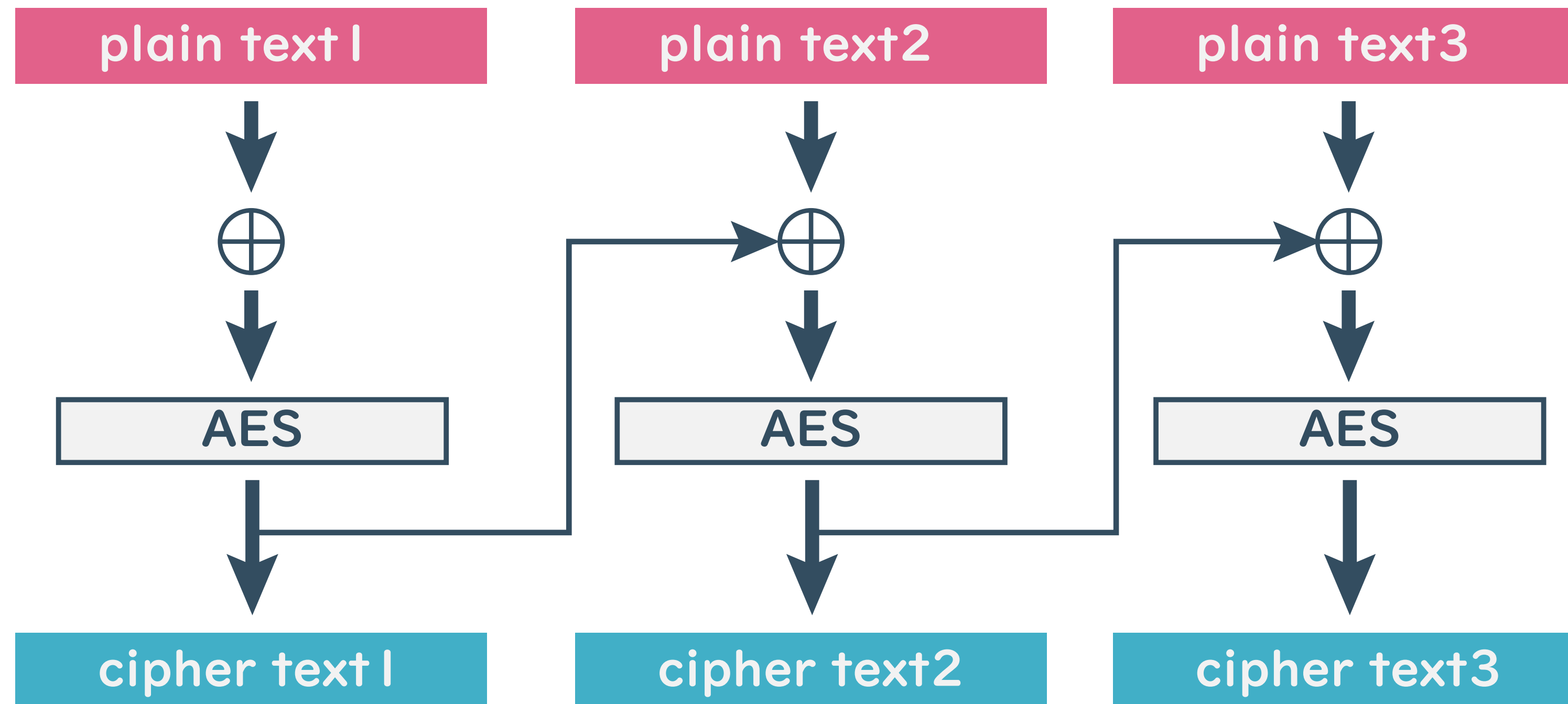


same plain text block leads to same cipher text block.  
So, confidentiality is low.

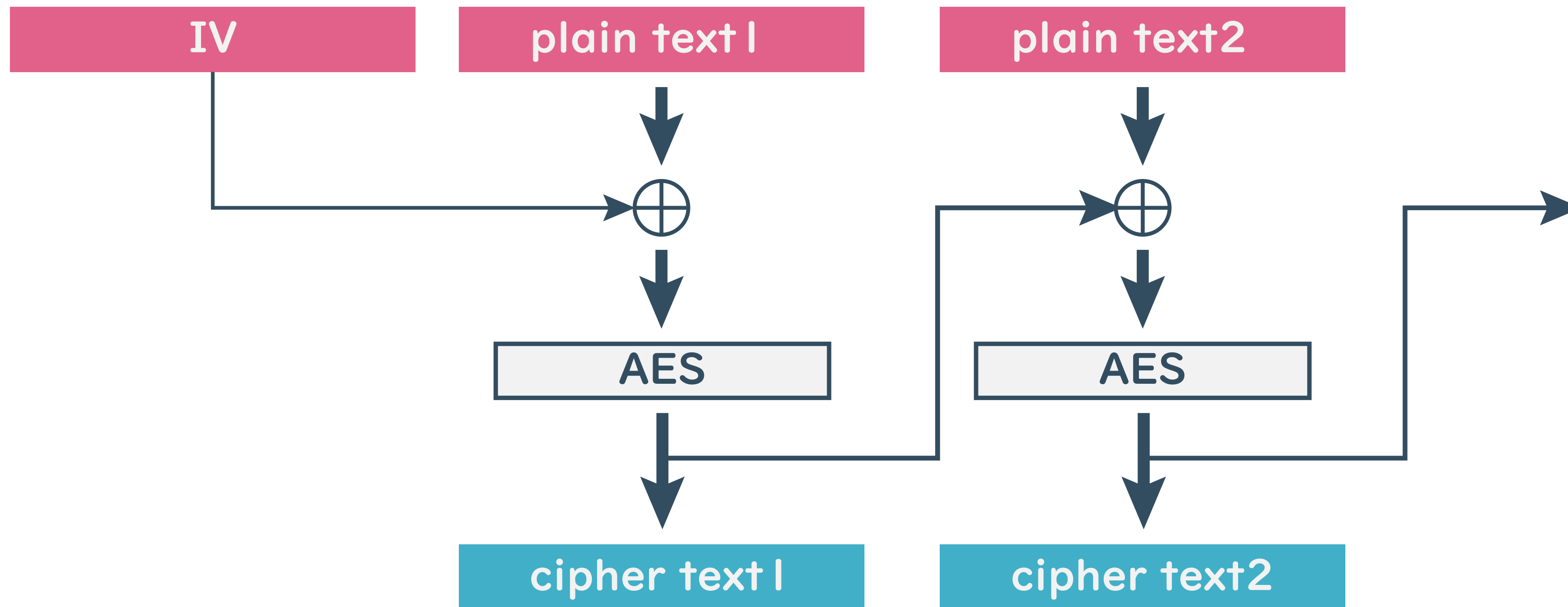


reference: [https://en.wikipedia.org/wiki/Block\\_cipher\\_mode\\_of\\_operation#ECB](https://en.wikipedia.org/wiki/Block_cipher_mode_of_operation#ECB)

Why is the ECB so weak?

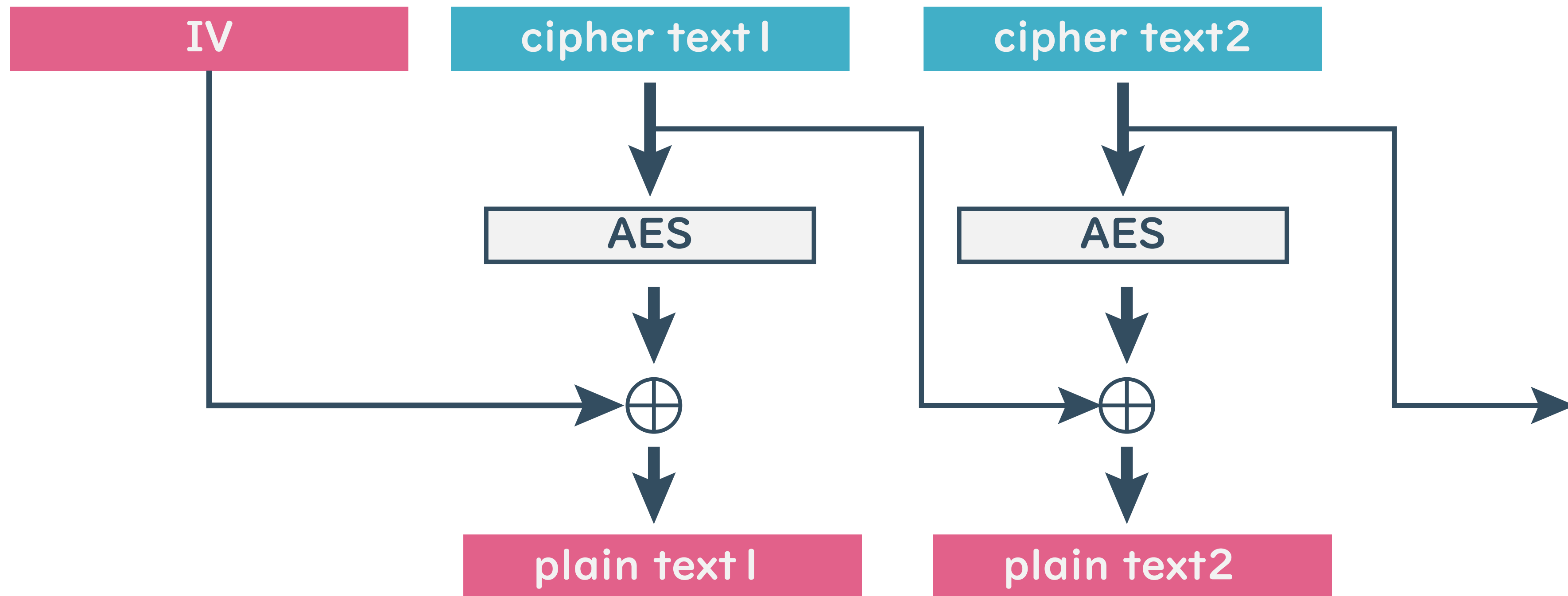


What's CBC?

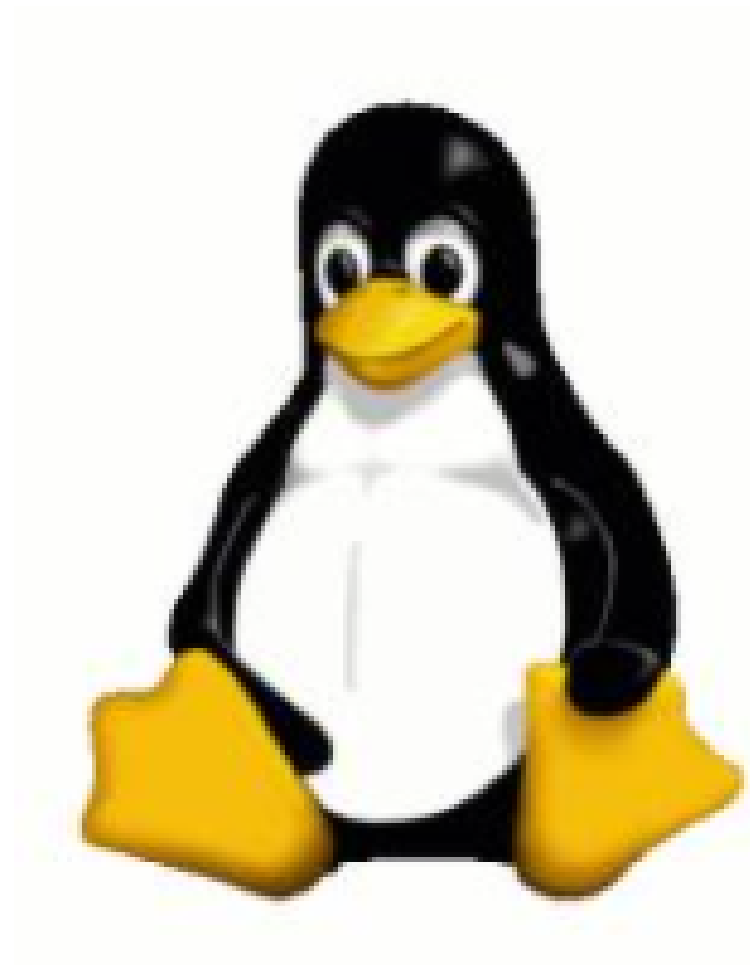


reference: [https://en.wikipedia.org/wiki/Block\\_cipher\\_mode\\_of\\_operation#ECB](https://en.wikipedia.org/wiki/Block_cipher_mode_of_operation#ECB)

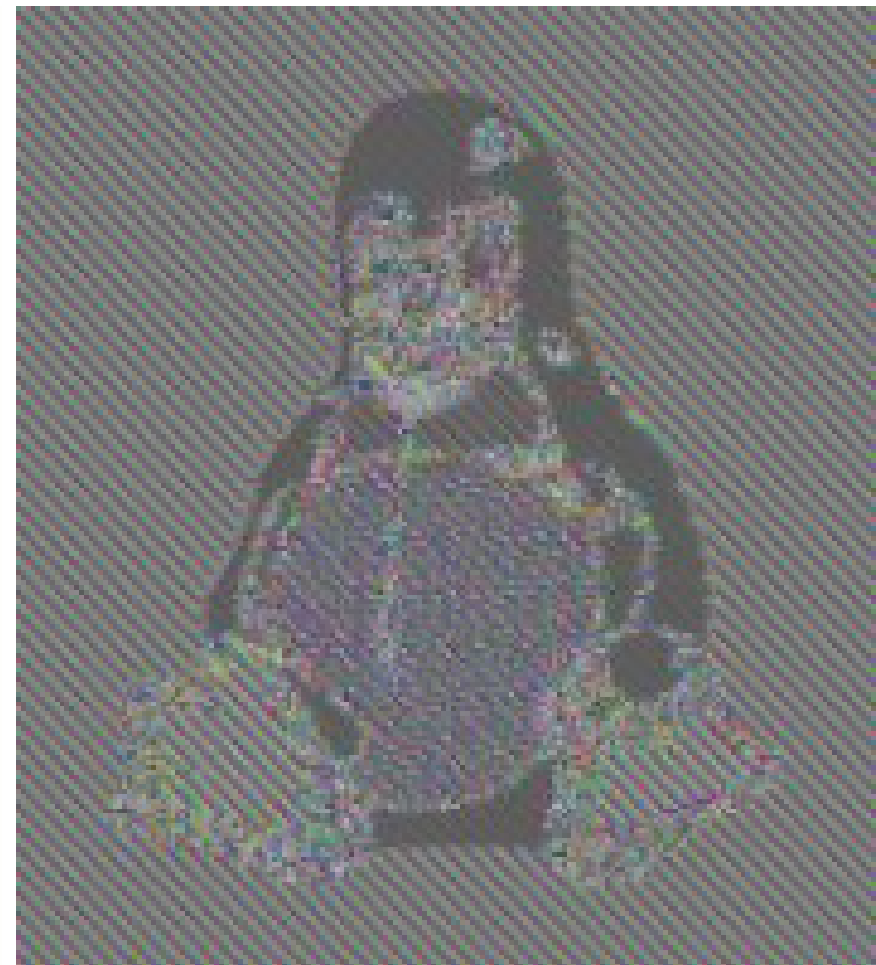
What's CBC?



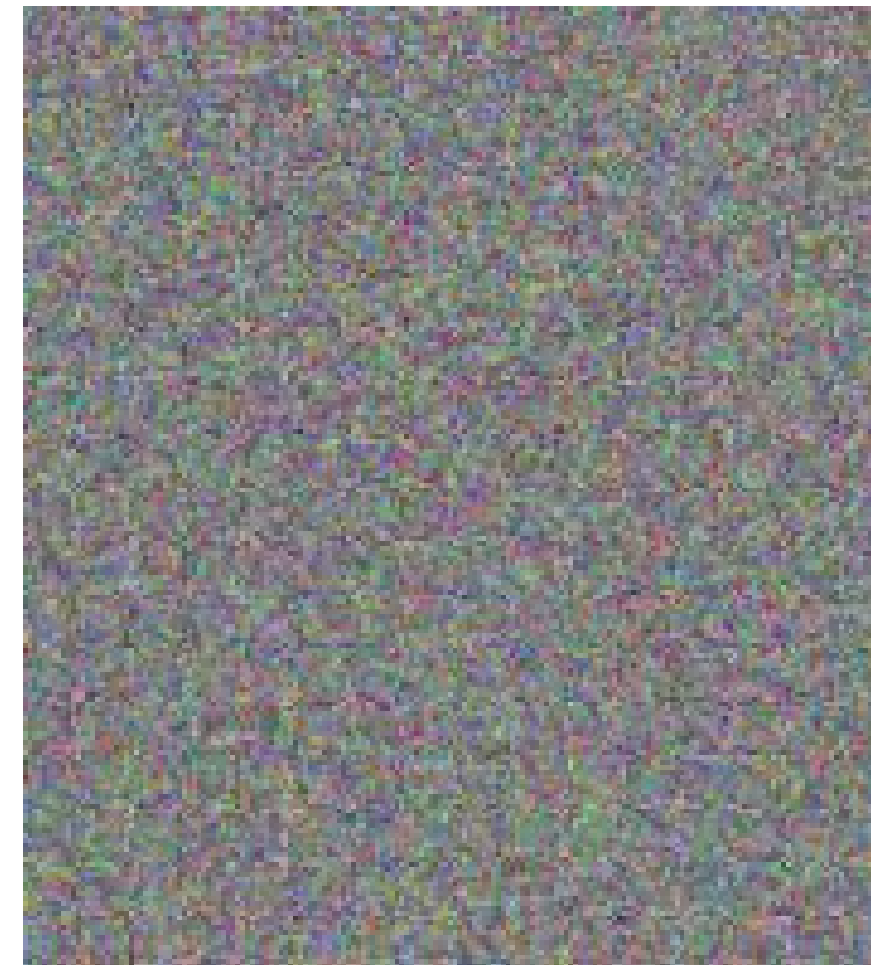
What's CBC?



Original bitmap  
image



Encrypted using  
ECB mode

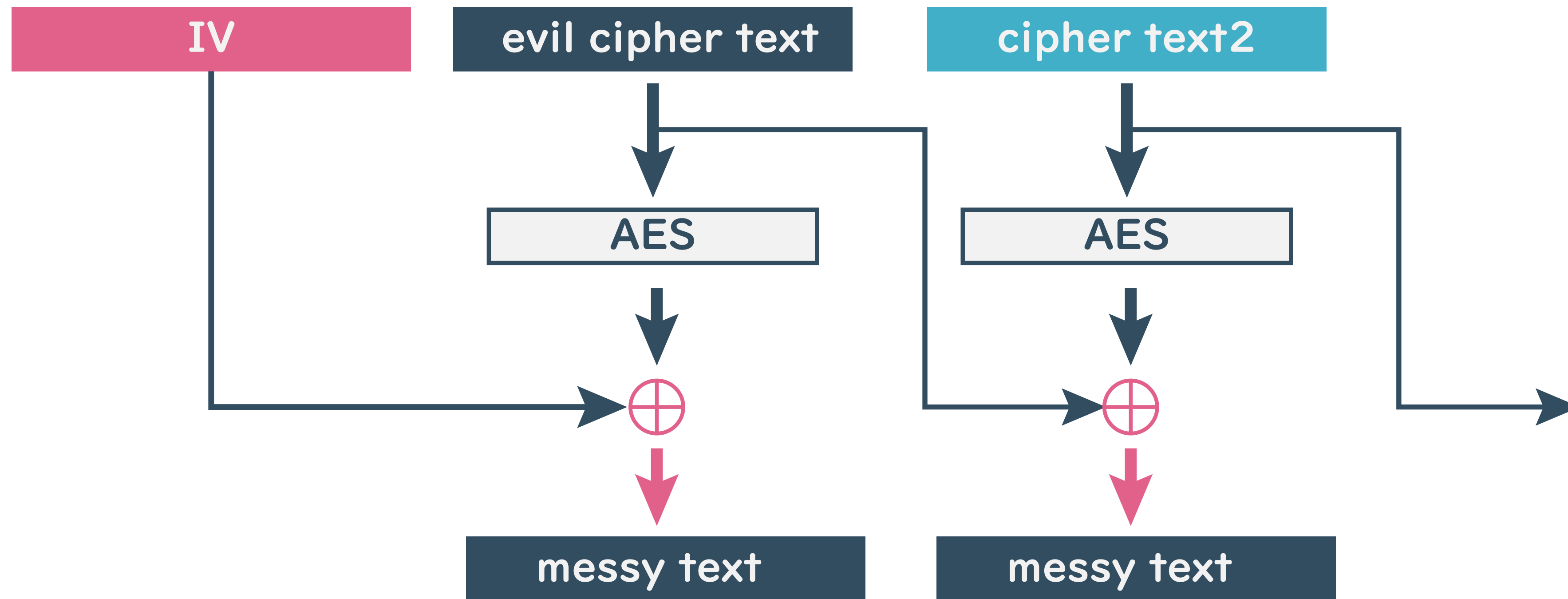


Encrypted using  
CBC mode



reference: <https://jiang-zhenghong.github.io/blogs/PaddingOracle.html>

What's CBC?



What's CBC?



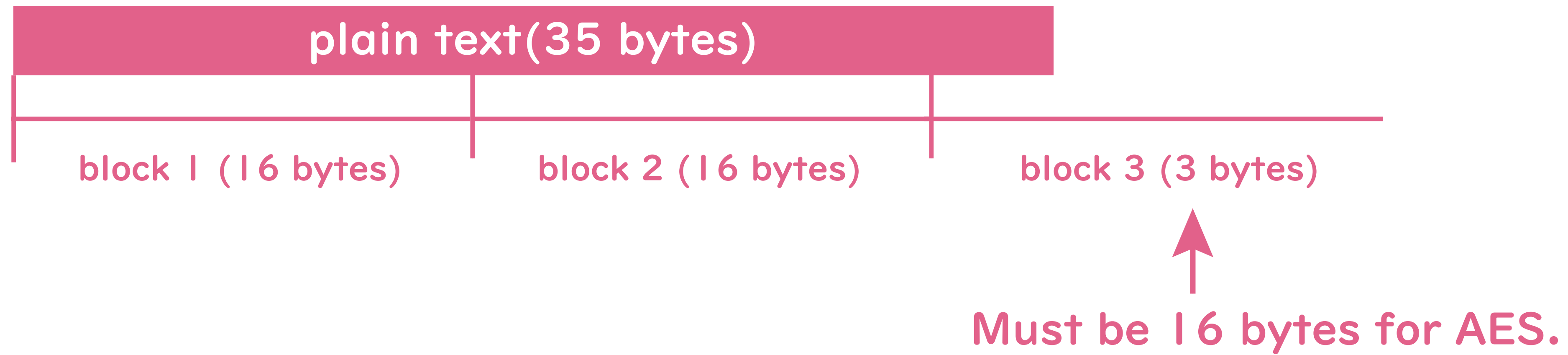
when we want to change **plain text 2**,  
evil cipher text 1 considering **cipher text 2**  
is needed.

So, we simple block exchange attack  
is not vaild.

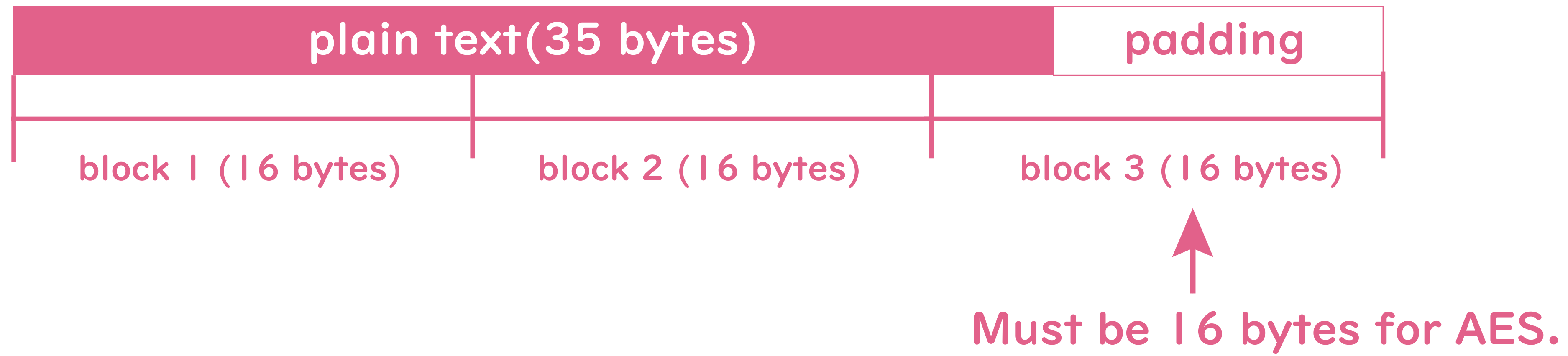
What's CBC?

But depending on how it is used,  
it could be weaker than the ECB.

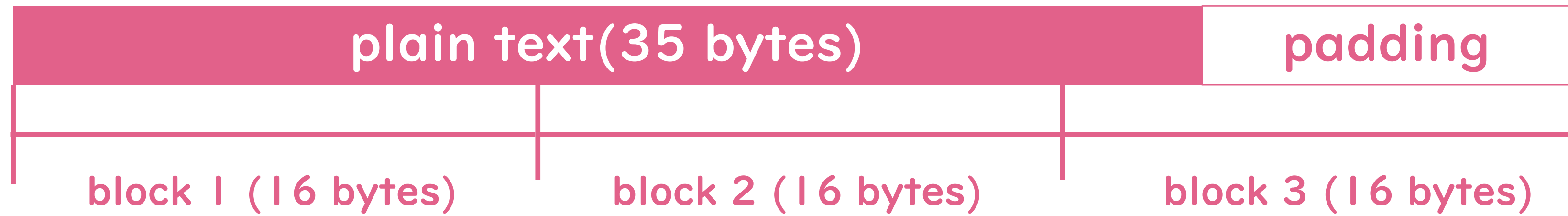




What's Padding?



What's Padding?



## what's padding?

[illegible]

described in PKCS#7

# What's Padding?

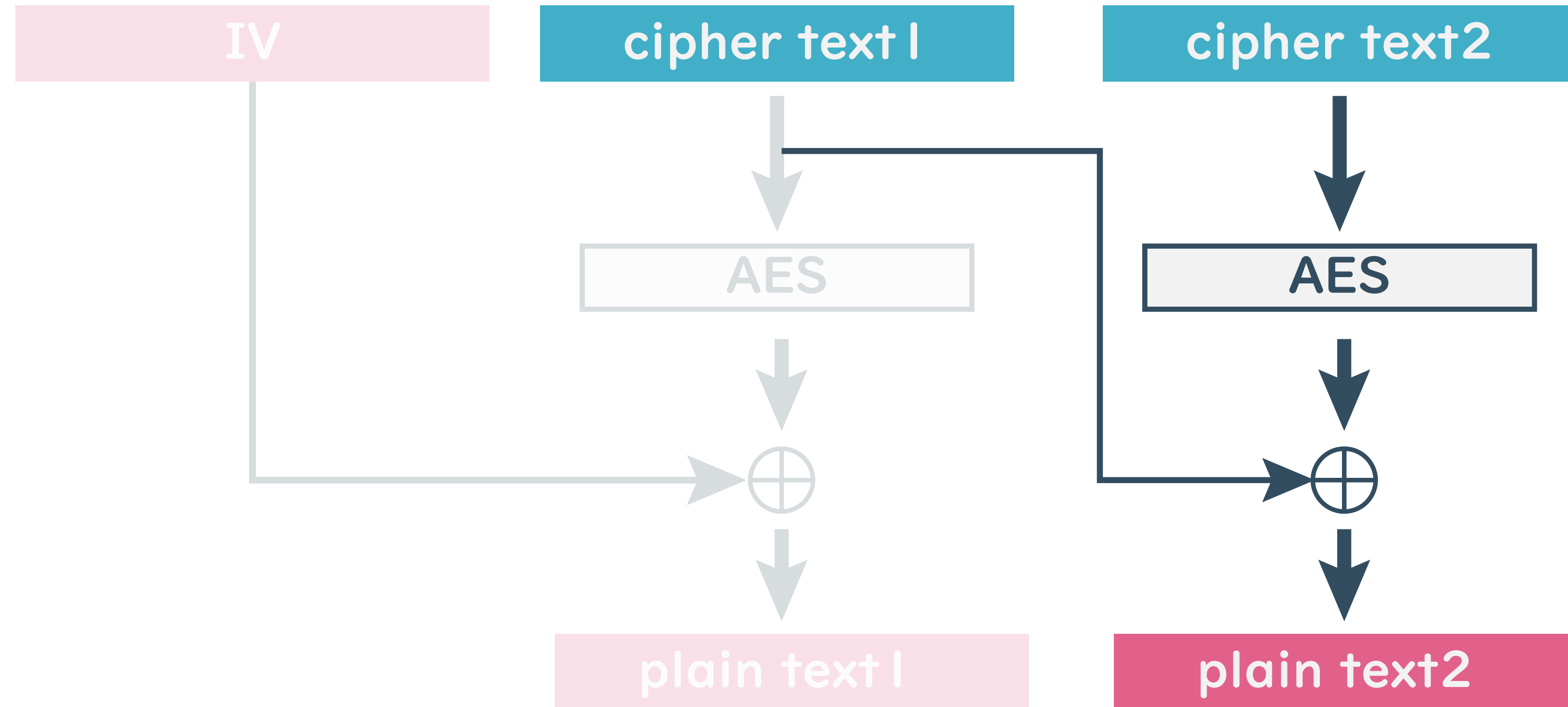
1. An attacker has (eavesdropped) cipher text
2. The cipher text is encrypted by CBC with PKCS#7 Padding
3. An attacker can know whether an arbitrary ciphertext is a padding error or not.



error!

→ Attacker can get plain text!

What's CBC Padding Oracle Attack?



$$\text{plain text2} = \text{AES}(\text{cipher text2}) \oplus \text{cipher text1}$$

# What's CBC Padding Oracle Attack?

cipher text I

12	23	12	ff	ae	32	12	33	a3	13	2a	3b	a2	23	a1	33
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----



**AES( cipher text2 )**

[illegible]

11

plain text2

[illegible]

cipher text1

12 23 12 ff ae 32 12 33 a3 13 2a 3b a2 23 a1 33



AES( cipher text2 )

? ? ? ? ? ? ? ? ? ? ? ? ? ? ?



plain text2

? ? ? ? ? ? ? ? ? ? ? ? ? ? ?

change last byte to  
0~255 (check all cases!)

cipher text1

12 23 12 ff ae 32 12 33 a3 13 2a 3b a2 23 a1 12



AES( cipher text2 )

? ? ? ? ? ? ? ? ? ? ? ? ? ? ?



plain text2

? ? ? ? ? ? ? ? ? ? ? ? ? ? ?

Padding Error!

when Almost all case,  
server response  
“padding error”



cipher text 1

12	23	12	ff	ae	32	12	33	a3	13	2a	3b	a2	23	a1	36
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----



AES( cipher text2 )

?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

||

plain text2

?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	01
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	----

Padding OK!

At that time, the attacker can know  
that **plain text 2** ends with **0x01**.

But one case,  
server response  
“padding OK”

cipher text 1

12	23	12	ff	ae	32	12	33	a3	13	2a	3b	a2	23	a1	36
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----



AES( cipher text2 )

?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

||

plain text2

?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	01
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	----

Padding OK!

$$\text{AES}(\text{cipher text2}) = 0x36 \wedge 0x01 = 0x37$$

cipher text1

12	23	12	ff	ae	32	12	33	a3	13	2a	3b	a2	23	a1	33
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----



AES( cipher text2 )

?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	37
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	----



plain text2

?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

$$\text{plain text2} = 0x33 \wedge 0x37 = 0x04$$

cipher text 1



$0x02 \wedge 0x37 = 0x35$

AES( cipher text2 )



plain text2



To expose second  
byte, set last byte  
to “0x02”

cipher text I

0~255

12	23	12	ff	ae	32	12	33	a3	13	2a	3b	a2	23	x	35
----	----	----	----	----	----	----	----	----	----	----	----	----	----	---	----



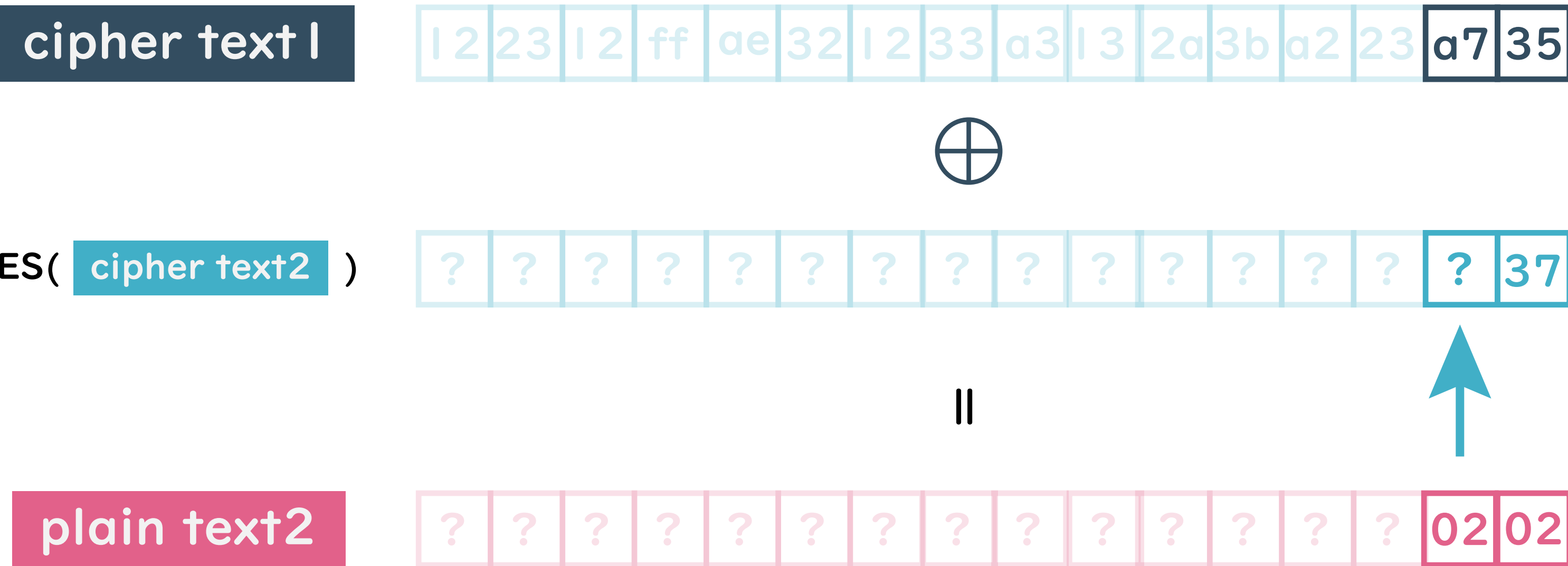
AES( cipher text2 )

[illegible]

11

plain text2

[illegible]



Padding OK!

$$\text{AES}(\text{cipher text2}) = 0xa7 \wedge 0x02 = 0xa5$$

cipher text1

12	23	12	ff	ae	32	12	33	a3	13	2a	3b	a2	23	a1	33
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----



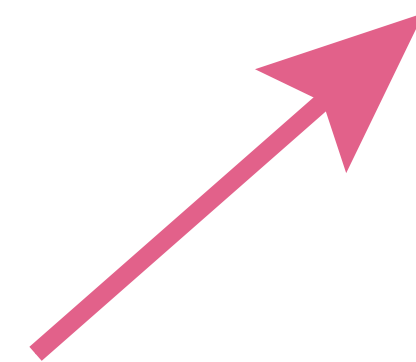
AES( cipher text2 )

?	?	?	?	?	?	?	?	?	?	?	?	?	?	a5	37
---	---	---	---	---	---	---	---	---	---	---	---	---	---	----	----

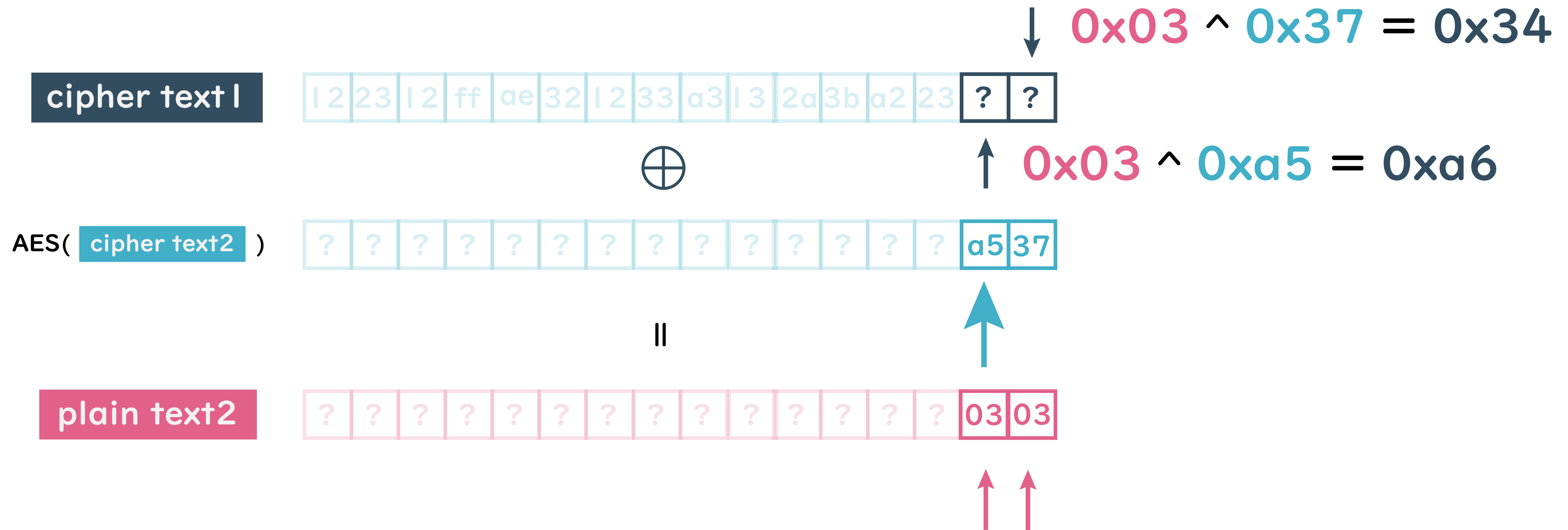


plain text2

?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	04
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	----

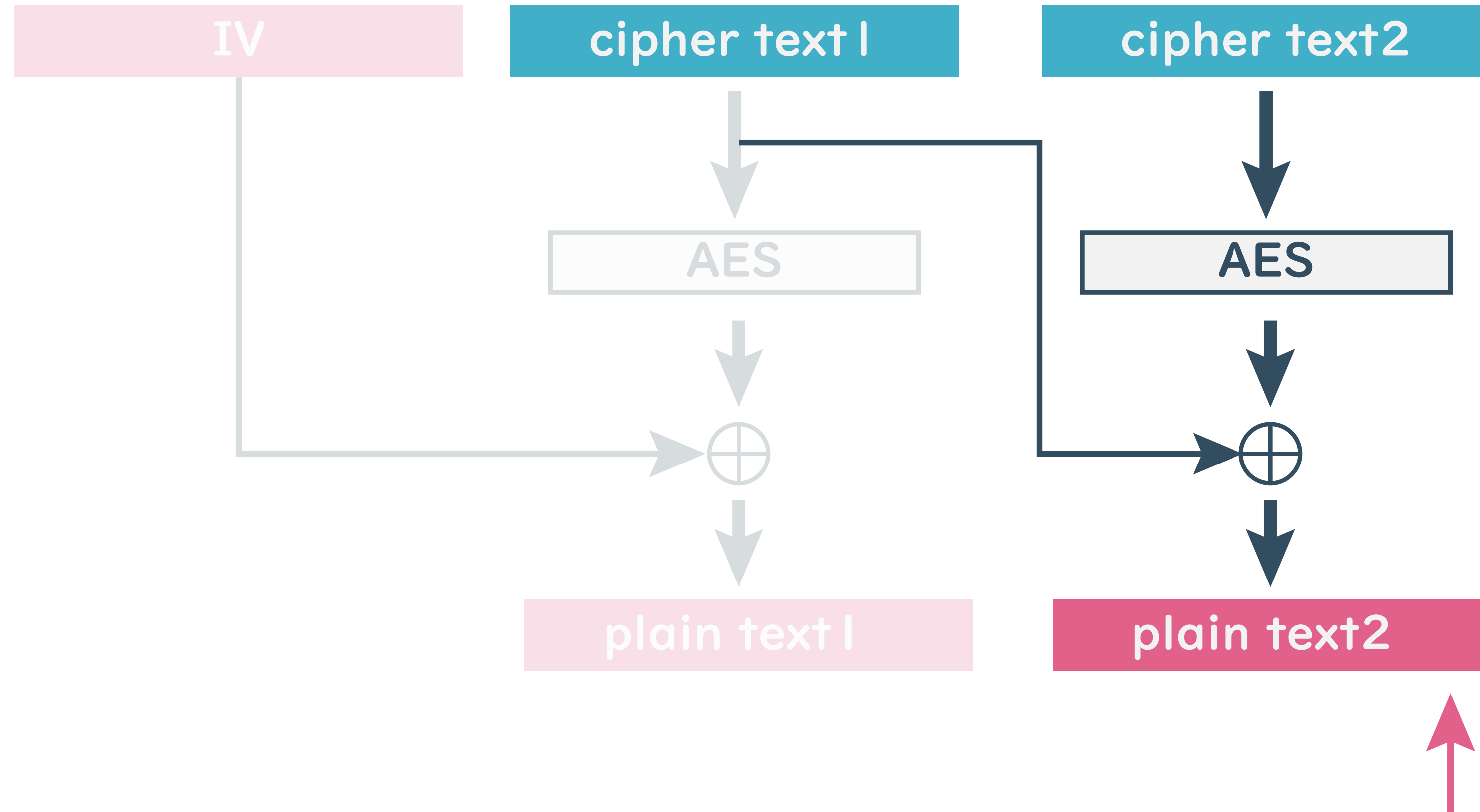


$$\text{plain text2} = 0xa1 \wedge 0xa5 = 0x04$$

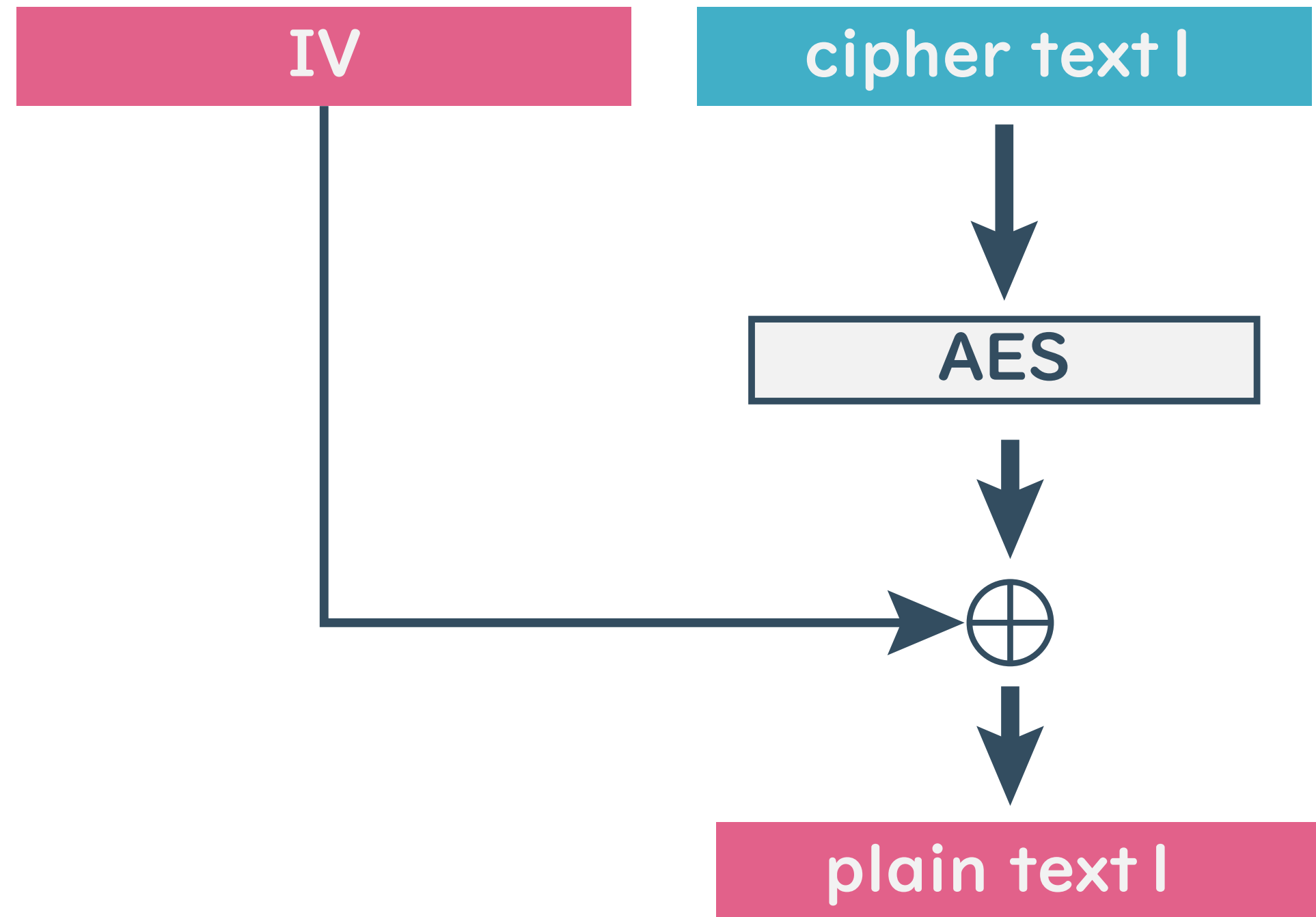


To expose third  
byte, set last byte  
to “0x03”

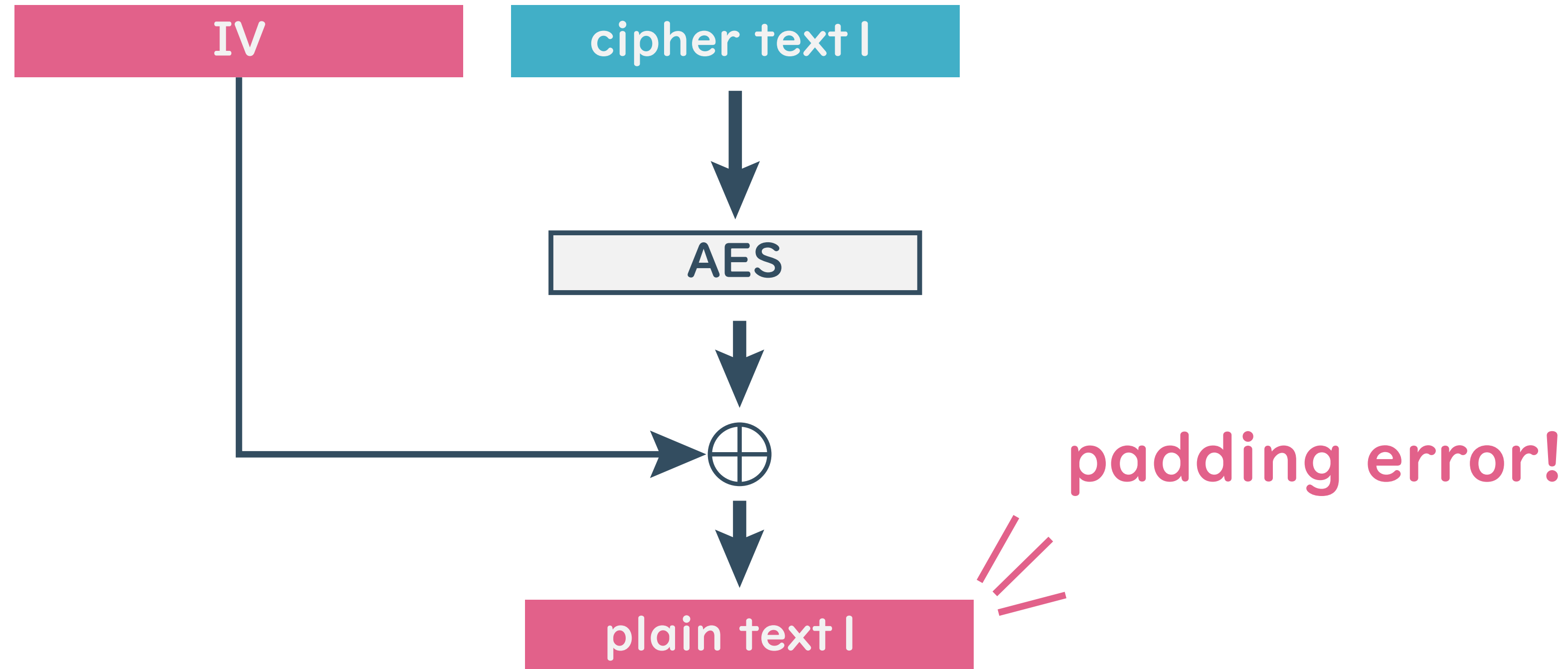




When we could expose all of plain text2,  
plain text 1 is next target!



When delete **cipher text 2**,  
**plain text 1** is last block



So, when we apply same algorithm in this situation, we can expose **plain text I** :)