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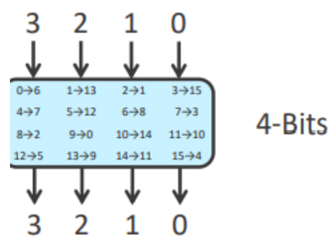
1 Block Ciphers

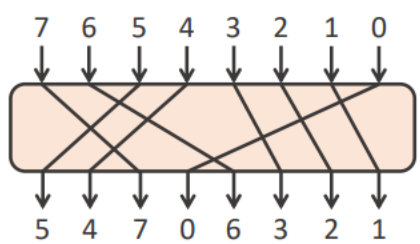
- Block ciphers use a key to encrypt a **fixed-size** block of plaintext into a **fixed-size** block of ciphertext
- If youre careful, you can convert between block and stream ciphers using modes of operation

2 SP-Networks

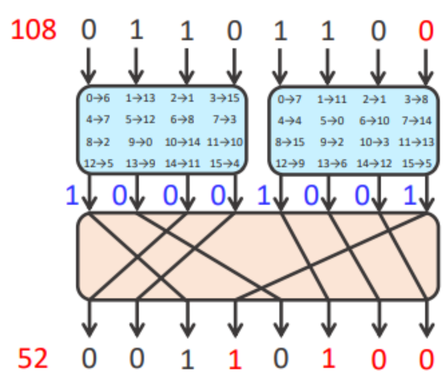
- SP-Networks combine a substitution process with a permutation into a single round
- Rounds are then repeated enough times to ensure the algorithm is secure
- **Substitution Boxes** Add confusion by replacing values with other values using a lookup table



- **Permutation Boxes** Add diffusion by moving values around from input to output



- Combined, result in:

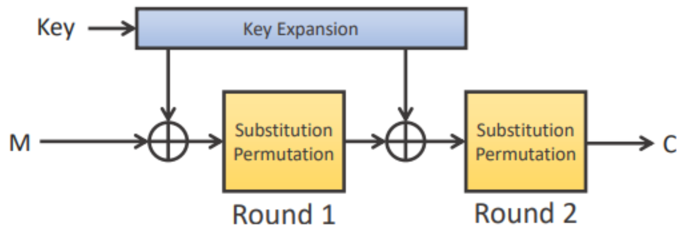


2.1 Notes

- One Round **isnt enough**!
- Careful analysis of input changes and output changes can reveal the contents of the S-boxes
- More rounds produces more diffusion
- Replacing permutation with linear transformation is more effective. Each bit is the XOR combination of multiple S-box outputs
- Typically the box size is around 128-bit and 256-bit.
- "Psuedorandomness" of the result is compromised with poor S-box design

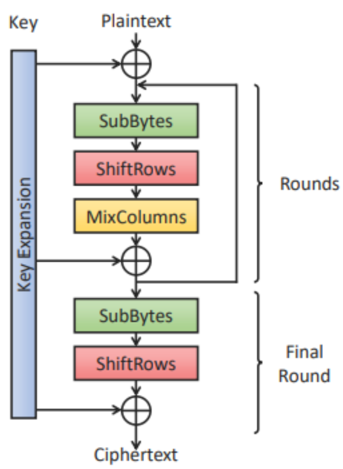
2.2 Key Mixing

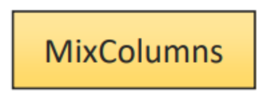
The previous SP-network didnt use a key, we can add one using XOR:



3 Advanced Encryption Standard

- Superseded DES as a standard in 2002. A standard built around the Rijndael algorithm
- Rijndael is an SP-Network with a 128-bit block size, and a key length of 128, 192 or 256-bits
- Round count depends on key length. 10, 12 or 14 cycles
- AES is vastly superior to DES, which had a 64-bit block and 56 bit key
- AES uses rounds of 4 layers, and a final round of 3. Bytes are represented as a 4x4 block called the state



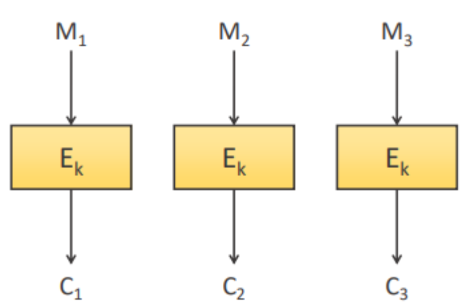


4 Block Cipher Modes

- Most messages dont come in convenient 128-block lengths
- Well need to run a block cipher repeatedly on consecutive blocks

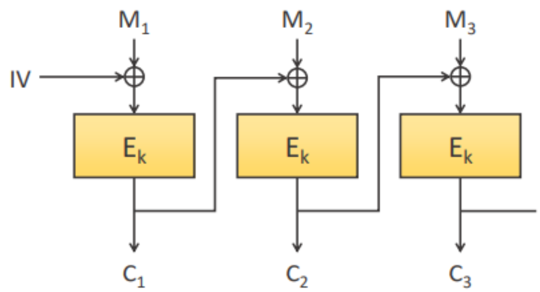
4.1 Electronic Code Book (ECB)

- Just encrypt each block one after another
- Weak to redundant data **divulging patterns**



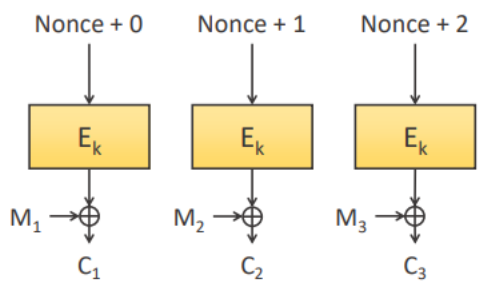
4.2 Cipher Block Chaining (CBC)

- Need to parse all previous content to get a bit in the middle.
- XOR the output of each cipher block with the next input
- Not totally immune to the insertion of malicious blocks



4.3 Counter Mode (CTR)

- Encrypting a counter
- Can be parallelized! 22 to produce a stream cipher
- Howerver if person intercepts and modify a message, it could cause issues



4.4 Galois Counter Mode (GCM)

- Extends counter mode to add authenticity: the sender definitely sent that message, and it hasnt changed
- Very similar to counter mode, but adds an authentication tag
- The tag is calculated using multiplication in a Galois Finite field GF(2128)
- Extremely parallelisable and robust to message alteration

5 Cryptographic attack models

Attack models weakest to strongest

- Brute-force - Go in blind, keep trying new keys, untill one matches.
- Ciphertext-only - Manually try to break the algorithm from investigatin cyphertext.
- Known-plaintext - We know the original message and cyphertext
- Chosen-plaintext - We choose the text and have it be encrypted. This way we have control of what's encrypted in order to help decrypt cyphertext
- Chosen-ciphertext - Also assumes that Chosen-plaintext is available.
- Related-key attack - Choose messages to be ecrypted and decrypted. By modifying keys around using mathematical properties, it possible to find out the process that's being done to encrypt the messages.

Reference section

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