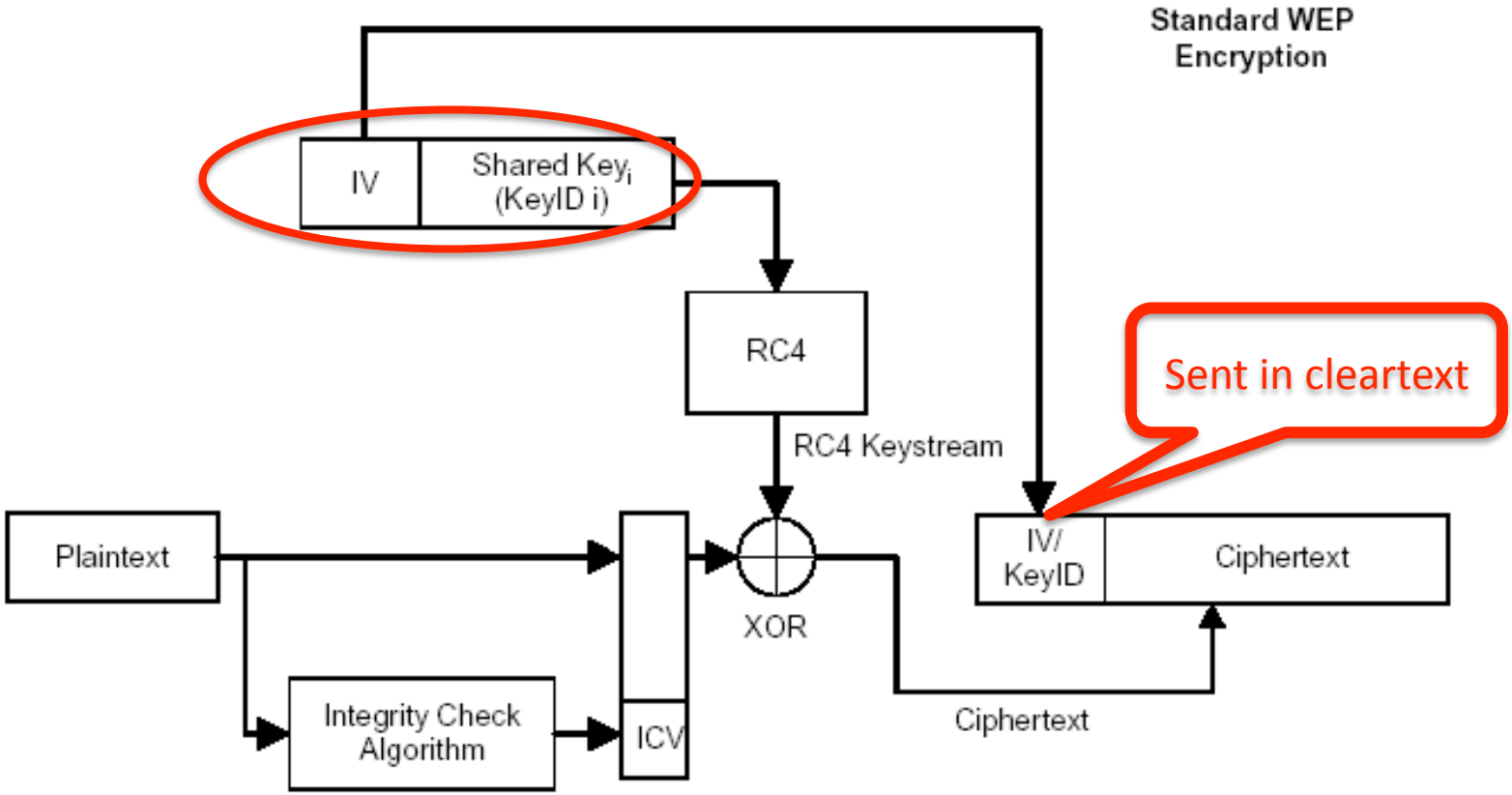
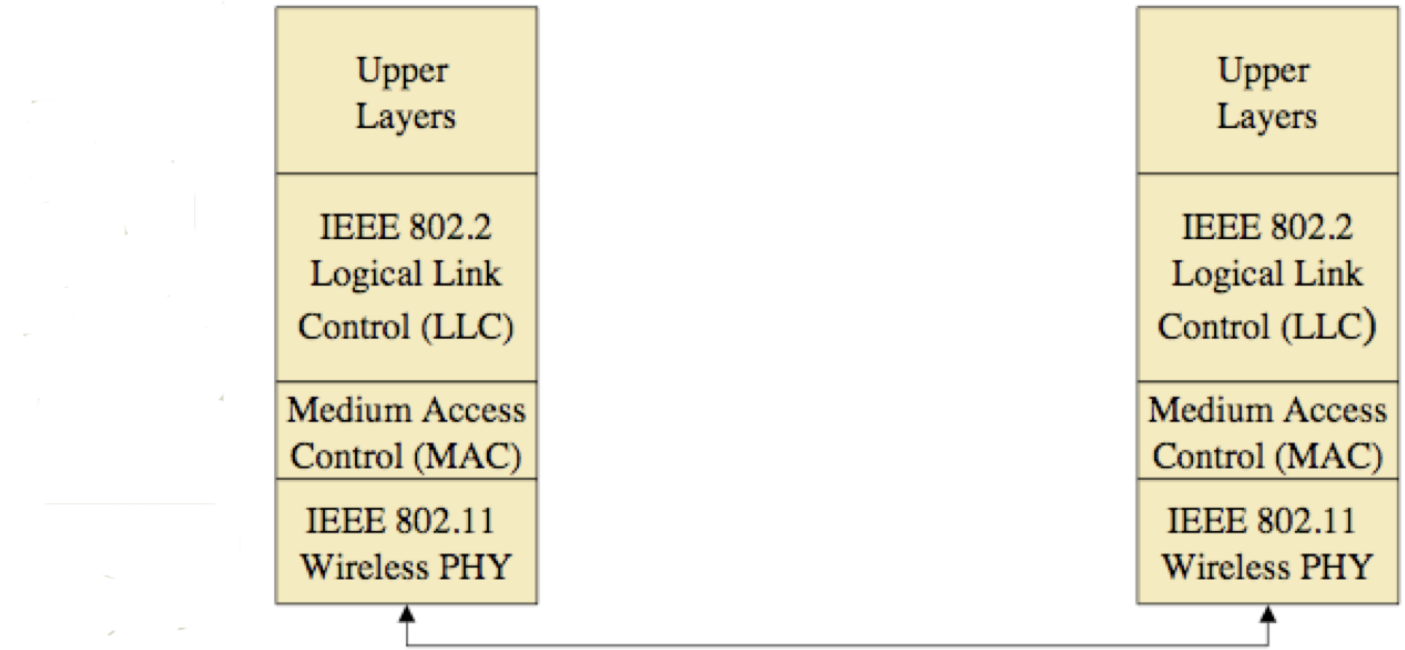
WEP

- Goals
  - Authentication
    - A pre-shared key K, shared among all APs and STAs members of the WLAN
    - Same key used for authentication and confidentiality
  - Confidentiality
    - RC4
  - Integrity Protection
    - CRC-32 (non-crypto primitive)

RC4

Figure 1. Standard WEP Encryption Process




Upper Layers
IEEE 802.2 Logical Link Control (LLC)
Medium Access Control (MAC)
IEEE 802.11 Wireless PHY
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IEEE 802.2 Logical Link Control (LLC)
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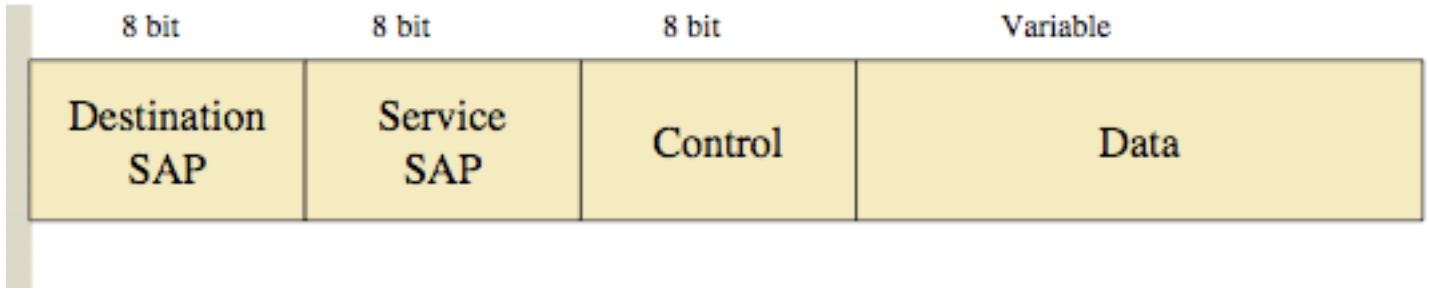

8 bit
8 bit
8 bit
Variable
Destination SAP
Service SAP
Control
Data

- RC4 uses the key and the IV to initialize a state machine via ksa()
- RC4 modifies the state and generates a new byte of the keystream from the new state using prga();
- first byte of the plaintext comes from the WEP SNAP header,
  - the first byte of the keystream can be obtained from

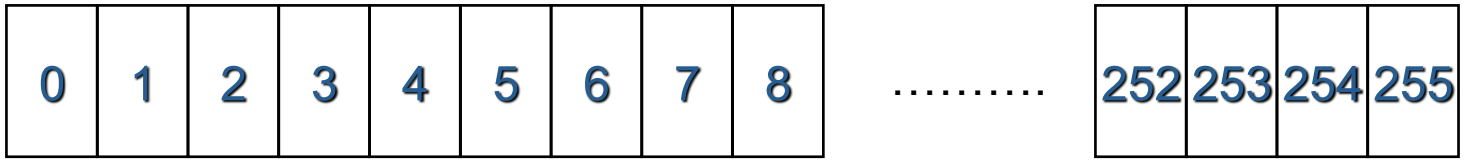
$$B \oplus 0xAA$$

- We can simulate the start of KSA because IV is sent in cleartext and K = IV|K
- Attacker knowing a byte of the keystream can derive a byte of the key (weakness in PRNG)
- Weak IV: (A+3, n-1, X)
  - Initialization vector that with 5% of probability allow to recover a byte of the key
  - The byte of keystream is linked to the value of the key

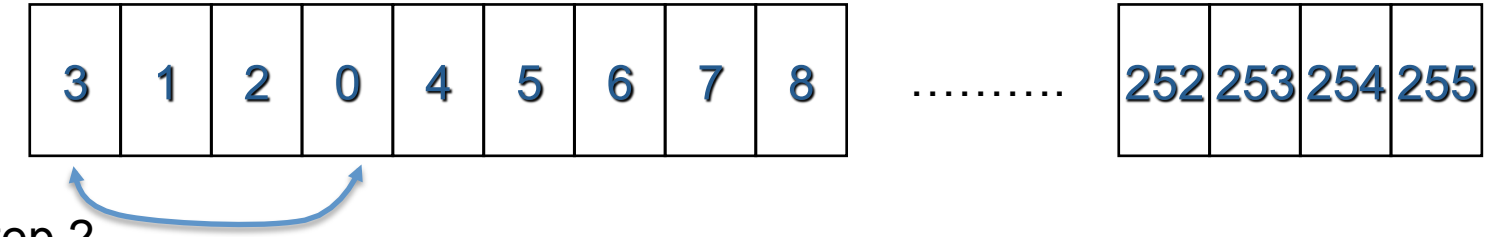
KSA

- key scheduling algorithm (KSA).
  - begin ksa(with int keylength, with byte key[keylength])
    - for i from 0 to 255
      - S[i] := i
    - Endfor
    - j := 0
    - for i from 0 to 255
      - j := (j + S[i] + key[i mod keylength]) mod 256
      - swap(S[i],S[j])
    - Endfor
    - end

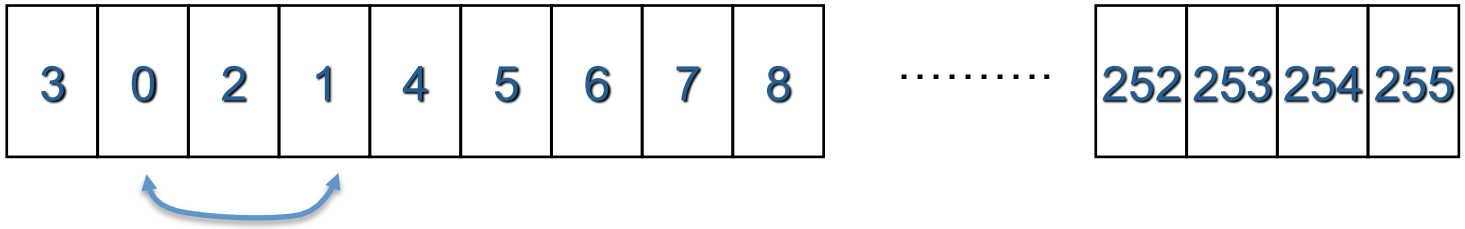
KSA: scrambling the byte array



Step 1



Step 2



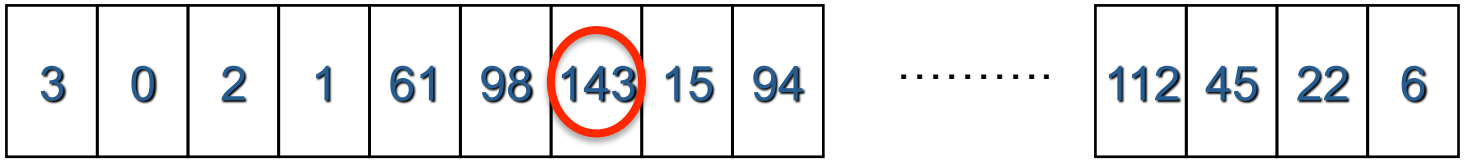
Step 3

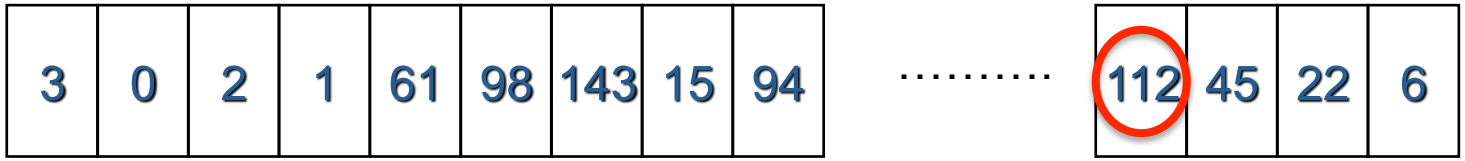
IV = 3,255,X

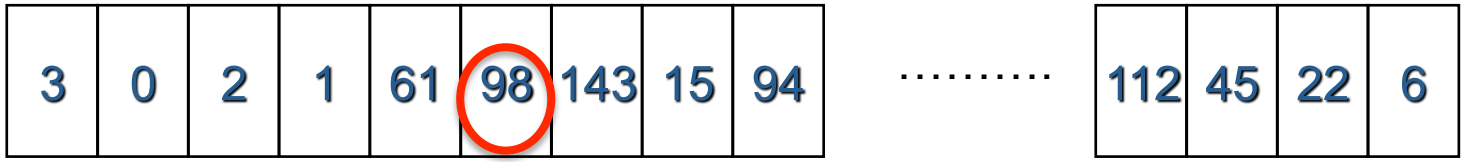
PRGA

- pseudo-random generation algorithm (PRGA)
  - begin prga(with byte S[256])
    - i := 0
    - j := 0
    - while GeneratingOutput:
      - i := (i + 1) mod 256
      - j := (j + S[i]) mod 256
      - swap(S[i],S[j])
      - output S[(S[i] + S[j]) mod 256]
    - Endwhile
  - end

PRGA: extract a byte of keystream







- If S is a permutation, S^{-1} is the inverse permutation
- If an attacker knows the first *l* bytes of an RC4 key used to generate a keystream X ().
  - He can simulate the first *l* steps of the RC4-KSA (S_l and j_l known)
  - $S_l[1] < l$
  - $S_l[1] + S_l[S_l[1]] = l$
  - $S^{-1}{}_l[X[0]] \neq 1$
  - $S^{-1}{}_l[X[0]] \neq S_l[1]$
- The function F() will take the value of K[*l*] with a probability of about 5%
  - $F(K[0], \ldots, K[l-1], X[0]) = S^{-1}[X[0]] - j - S[l]$

WPA-PSK

[Message 1: A → S]

AA, ANonce, sn, msg1

[Message 2: S → A]

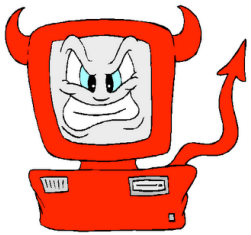
SPA, SNonce, sn, msg2, MIC_{PTK}{SNonce, sn, msg2}

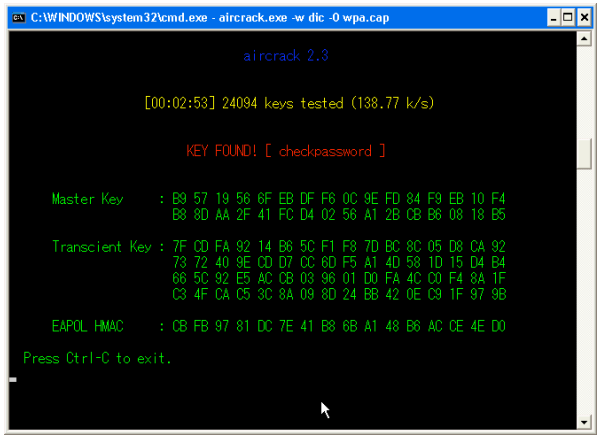
[Message 3: A → S]

AA, ANonce, sn+1, msg3, MIC_{PTK}{ANonce, sn+1, msg3}

[Message 4: S → A]

SPA, sn+1, msg4, MIC_{PTK}{sn+1, msg4}




C:\WINDOWS\system32\cmd.exe - aircrack.exe -w dic -0 wpa.cap
aircrack 2.3
[00:02:53] 24094 keys tested (138.77 k/s)
KEY FOUND! [checkpassword]
Master Key : B9 57 19 56 6F EB DF F6 0C 9E FD 84 F9 EB 10 F4
B8 8D AA 2F 41 FC D4 02 56 A1 2B CB B6 08 18 B5
Transcient Key : 7F CD FA 92 14 B6 5C F1 F8 7D BC 8C 05 D8 CA 92
73 72 40 9E CD D7 CC 6D F5 A1 4D 58 1D 15 D4 B4
66 5C 92 E5 AC CB 03 96 01 D0 FA 4C C0 F4 8A 1F
C3 4F CA C5 3C 8A 09 8D 24 BB 42 0E C9 1F 97 9B
EAPOL HMAC : CB FB 97 81 DC 7E 41 B8 6B A1 48 B6 AC CE 4E D0
Press Ctrl-C to exit.

- **Password cracker (GPLv2 Licence)**
  - http://www.openwall.com/john/
  - Support for DES, MD5, Blowfish and others
- **Single Crack Mode**
  - Uses correlation with “username field”
- **Wordlist mode**
  - Dictionary password attack
    - Dictionaries at ftp://ftp.ox.ac.uk/pub/wordlists
- **Incremental Mode**
  - it can try all character combinations as passwords
- **External Mode**
  - heavily programmable

- **Syntax based on Crack 5.0a**
  - **ftp://ftp.cert.dfn.de/pub/tools/password/Crack/**
- **Examples:**
  - **-c[rules]:ignore this rule if password are not case sensitive**
  - **> 3: do no process di word of smaller than 3 characters**
  - **/: convert alla characters to lowecase**