Computer Security

Stream Cipher

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Symmetric key crypto

- Stream cipher — based on one-time pad
  - Except that key is relatively short
  - Key is stretched into a long keystream
  - Keystream is used just like a one-time pad
  - RC4, A5/1, and etc.
- Block cipher — based on codebook concept
  - Block cipher key determines a codebook
  - Each key yields a different codebook
  - Employs both “confusion” and “diffusion”

Stream Ciphers: making OTP practical

Idea: Replace “random” key by “pseudorandom” key

$PRG\ is\ a\ fuction\ G: \{0, 1\}^s \rightarrow \{0, 1\}^n$

Generate a pseudo random key using a random seed!

Encryption: $c = G(k) \oplus m$

Security will depend on specific PRG G

Quiz

Can a stream cipher have perfect secrecy?

No, since the key is shorter than the message

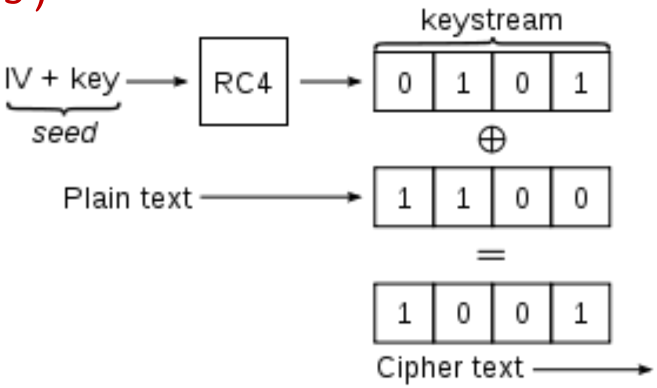
RC4 stream cipher

- A proprietary cipher owned by RSA, designed by Ron Rivest in 1987
- Became public in 1994
- Simple and effective design
- Variable key size (typical 40 to 256 bits)
- Output unbounded number of bytes
- Widely used (SSL/TLS, wireless WEP)
- Extensively studied, not a completely secure PRNG
- Newer Versions: RC5 and RC6

Stream cipher example - RC4

- Key stream generation:
  - (S[] is permutation of 0,1,...,255)

```
i:= i+1    (mod 256)
j:= j+s[i](mod 256)
swap(s[i],s[j])
t:= s[i]+s[j]  (mod 256)
k:= s[t]
```



- Idea: systematically keep swapping and producing output bytes (i.e., S [ ])

Security of RC4

- RC4 is not a truly pseudorandom generator.
- The keystream generated by RC4 is biased.
  - The second byte is biased toward zero with high probability.
  - The first few bytes are strongly non-random and leak information about the input key.
- Defense: Discard the initial *n* bytes of the keystream.
  - Called “RC4-drop[*n*-bytes]”.
  - Recommended values for *n* = 256, 768, or 3072 bytes.

Trends of stream ciphers

- Stream ciphers were popular in the past
  - Efficient in hardware
  - Speed was needed to keep up with voice, etc.
  - Today, processors are fast, so software-based crypto is usually more than fast enough
- Future of stream ciphers?
  - Shamir declared “the death of stream ciphers”
  - May be greatly exaggerated…

Questions?

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