CS631 - Advanced Programming in the UNIX Environment
–
Encryption in a Nutshell

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Purpose of Encryption

Encryption provides Security! Duh.

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- Accuracy or Integrity
- Secrecy or Confidentiality

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  - *Did/could anybody else see (parts of) the message?*

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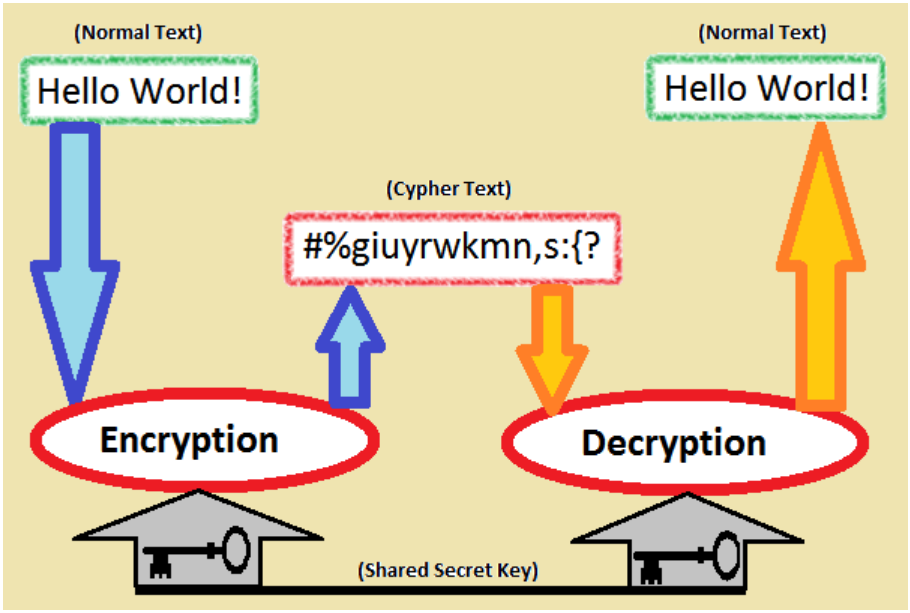
- *Alice* Edward and *Bob* Glenn agree on a way to transform data
- transformed data is sent over insecure channel
- Edward and Glenn are able to get data out of the transformation



How does encryption work?

Different approaches:

- secret key cryptography
- public key cryptography

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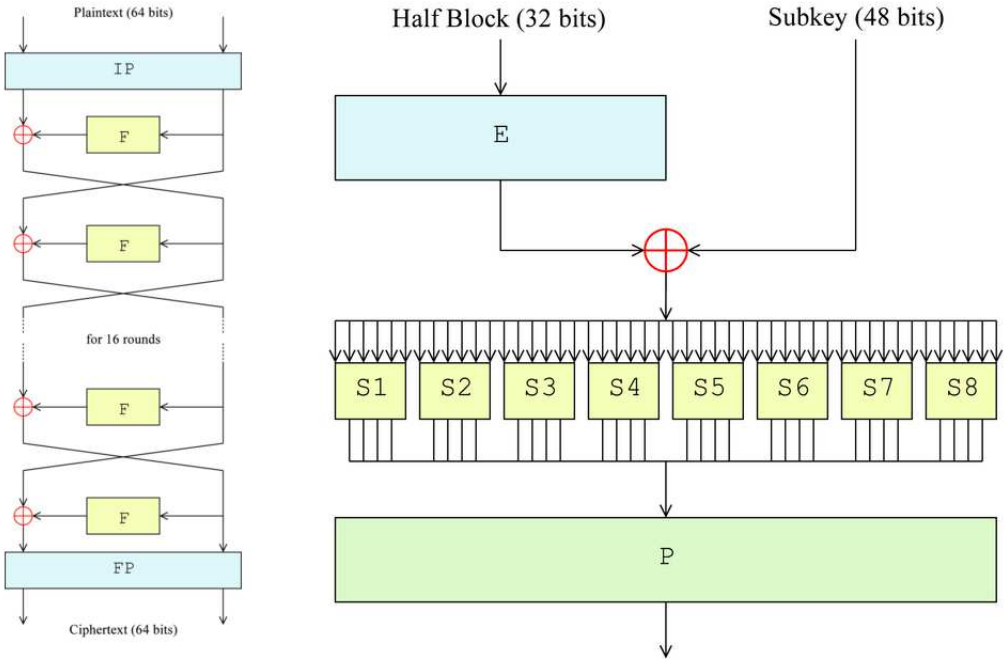
Different approaches:

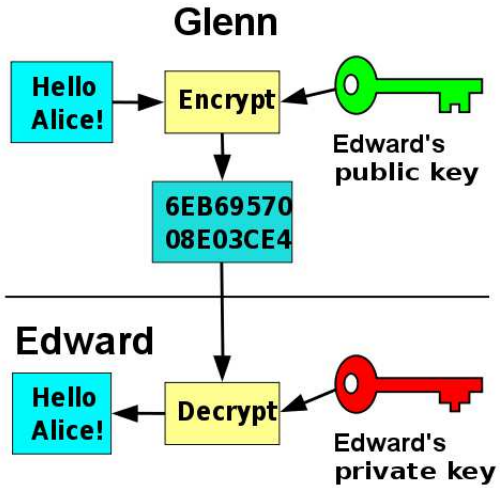
- secret key cryptography (example: *DES*)
  - Edward and Glenn share a secret
  - Edward can prove to Glenn that he knows a secret



How does encryption work?

Different approaches:

- public key cryptography (example: *RSA*)
  - Edward has a private and a public key
  - data encrypted with her private key can only be decrypted by her public key and vice versa
  - public key can be shared with Glenn



Accuracy or Integrity

In order to protect against forgery or data manipulation, provide some sort of digest or checksum (often a one-way hash). Popular choices:

- `5f4dcc3b5aa765d61d8327deb882cf99`
- `5baa61e4c9b93f3f0682250b6cf8331b7ee68fd8`
- `5e884898da28047151d0e56f8dc6292773603d0d6aabbdd62a11ef721d1542d8`
- `b109f3bbbc244eb82441917ed06d618b9008dd09b3befd1b5e07394c706a8bb980b1d7785e5976ec049b46df5f1326af5a2ea6d103fd07c95385ffab0cacbc86`

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- `5f4dcc3b5aa765d61d8327deb882cf99` (MD5)
- `5baa61e4c9b93f3f0682250b6cf8331b7ee68fd8` (SHA-1)
- `5e884898da28047151d0e56f8dc6292773603d0d6aabbdd62a11ef721d1542d8` (SHA256)
- `b109f3bbbc244eb82441917ed06d618b9008dd09b3befd1b5e07394c706a8bb980b1d7785e5976ec049b46df5f1326af5a2ea6d103fd07c95385ffab0cacbc86` (SHA512)

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Caveats:

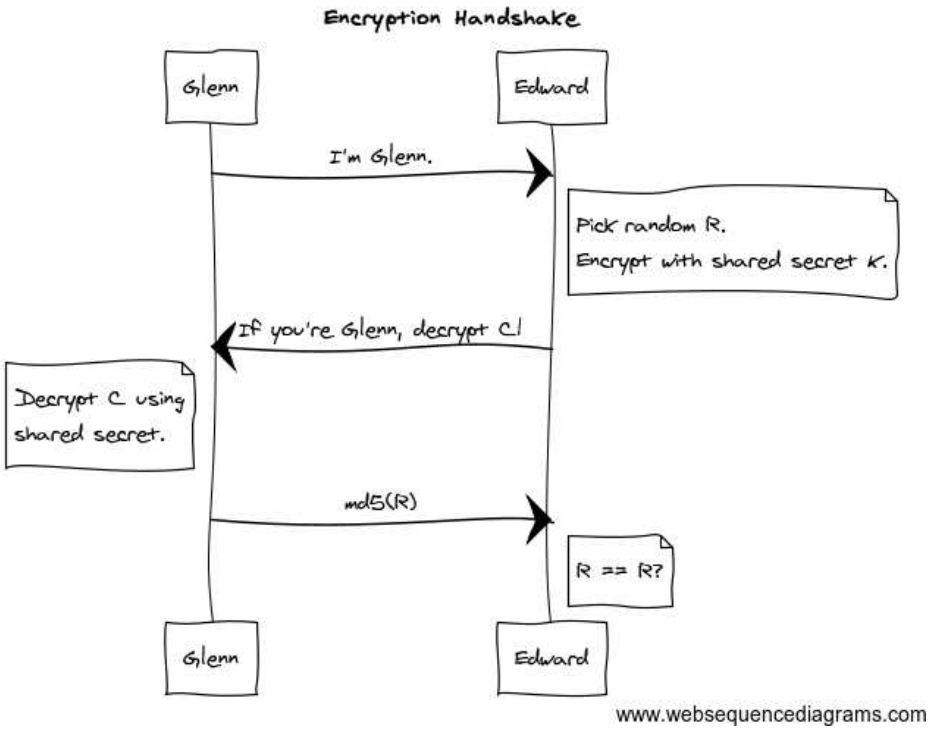
- “rainbow tables” / internet search engines allow for easy reverse lookup of un-salted hashes.
- integrity only ensured if authenticity of information itself is guaranteed

Authenticity

- in private key cryptography, authenticity is (often) assumed/implied
- in public key cryptography, often accomplished via a separate signature
- ways to establish assurance of authenticity for parties that have never met:
  - public key infrastructures (PKI) and certificate authorities (CA)
  - “web of trust”

Authentication

First, the client needs to prove that it knows the secret. This is done in the encryption handshake, consisting of a *challenge* and a *response*.



Random String generation

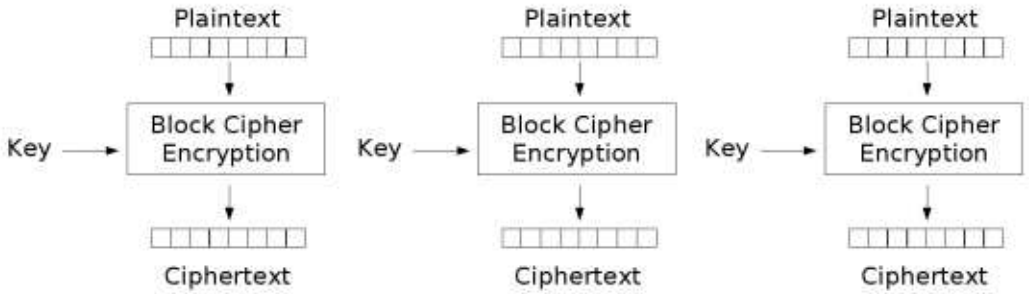
Random numbers can be generated using `/dev/random`, `/dev/urandom`, `rand(3)`, `random(3)`, `BN_rand(3)` etc.

Map numbers to printable characters (for use as a salt, for example):

```
static const unsigned char itoa64[] =
        "./0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz";

char salt[16];
for (i=0; i<16; i++)
        salt[i] = itoa64[(int)random()%64];
```

Electronic Codebook Mode



Electronic Codebook (ECB) mode encryption

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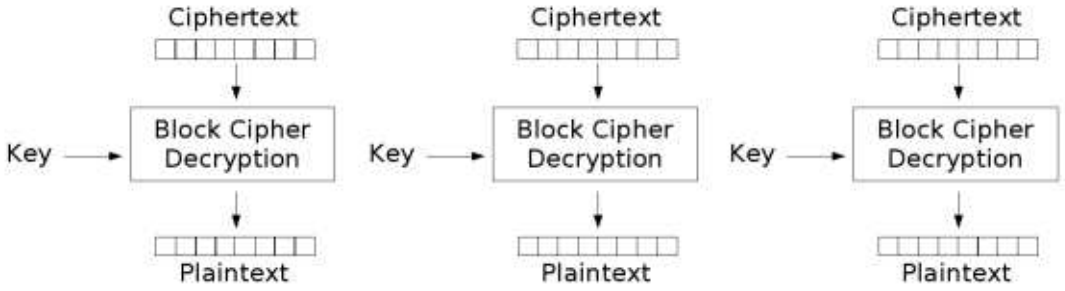
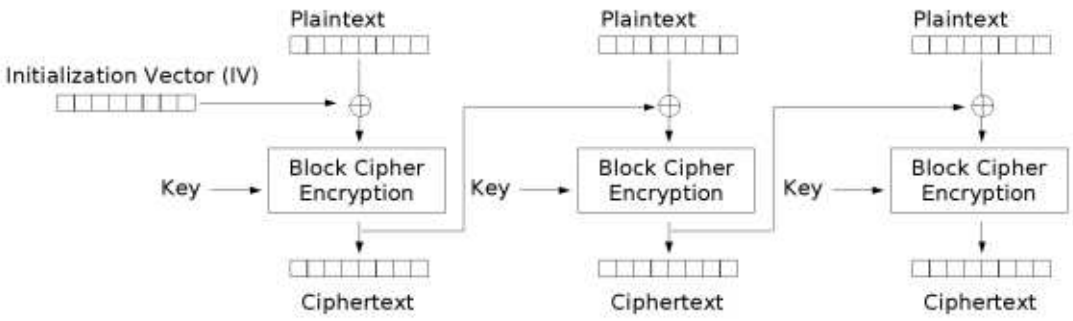


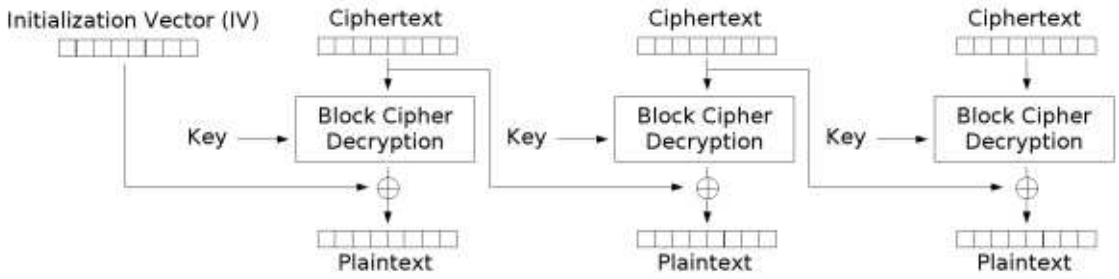
Electronic Codebook (ECB) mode decryption

Cipher Block Chaining



Cipher Block Chaining (CBC) mode encryption

Cipher Block Chaining



Cipher Block Chaining (CBC) mode decryption

Practical AES

- a symmetric block cipher
- variable key length
- consists of a key setup phase and the actual encryption or decryption
- keying material use of `ivec`, which needs to be shared

HW#5

`http://www.cs.stevens.edu/~jschauma/631/f13-hw5.html`

References

OpenSSL's crypto libraries:

- `crypto(3)`
- `EVP_EncryptInit(3)`
- `EVP_BytesToKey(3)`
- `http://tldp.org/LDP/LG/issue87/vinayak.html`
- `http://en.wikipedia.org/wiki/Cipher_Block_Chaining`
- `http://www.moserware.com/2009/09/stick-figure-guide-to-advanced.html`