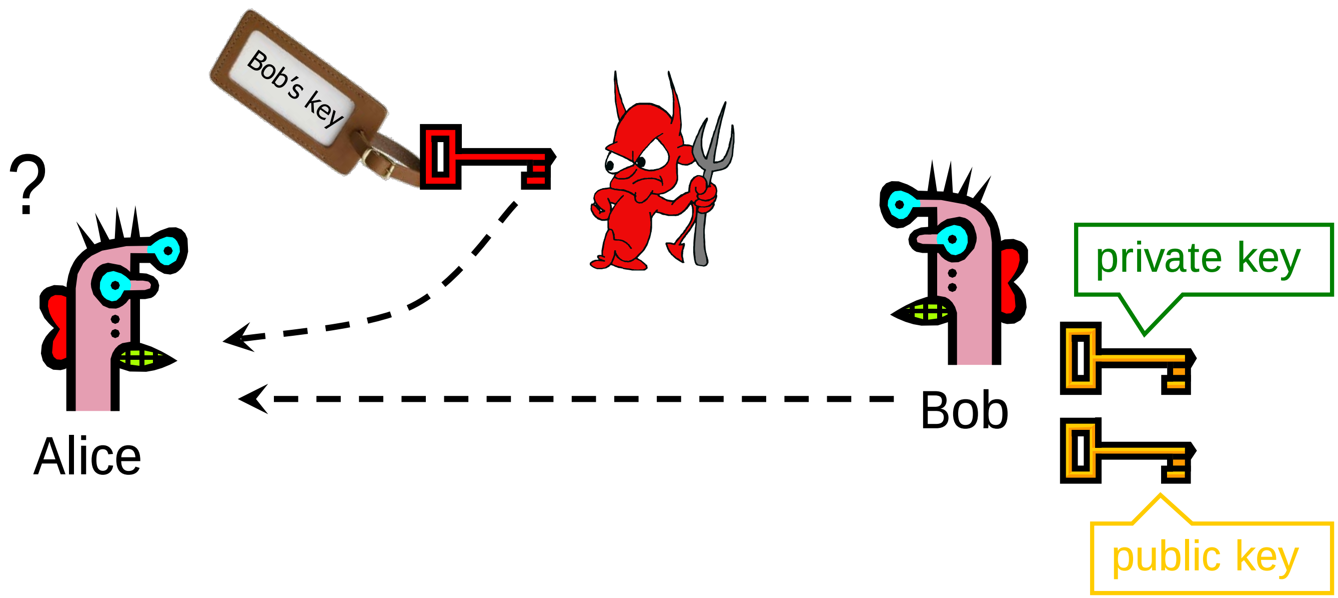
Public-Key Infrastructure NETS E2008

Many slides from
Vitaly Shmatikov, UT Austin

Authenticity of Public Keys



Problem: How does Alice know that the public key she received is really Bob's public key?

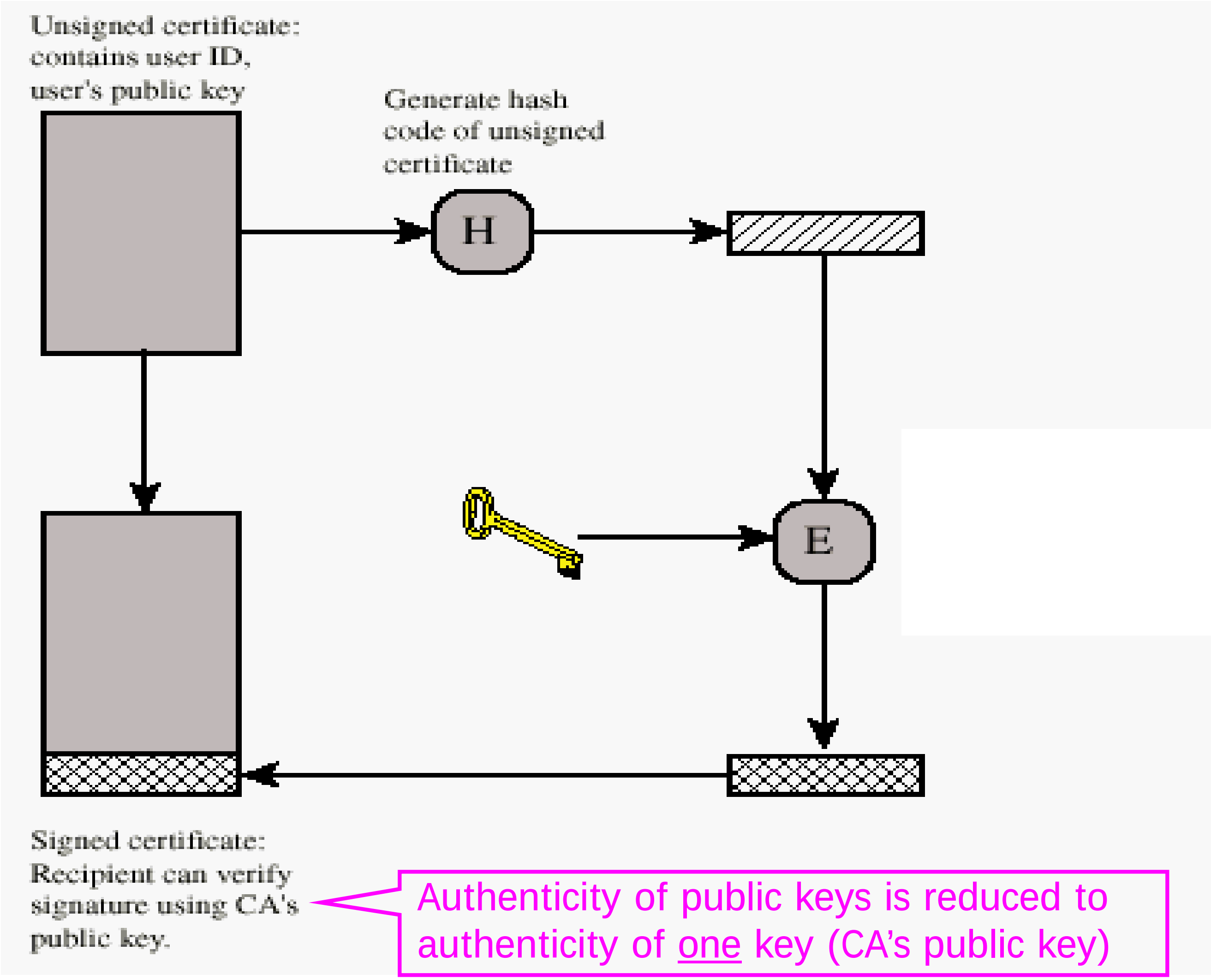
Distribution of Public Keys

- Public announcement or public directory
  - Risks: forgery and tampering
- Public-key certificate
  - Signed statement specifying the key and identity
    - sig_{Alice}(“Bob”, PK_B)
- Common approach: certificate authority (CA)
  - Single agency responsible for certifying public keys
  - After generating a private/public key pair, user proves his identity and knowledge of the private key to obtain CA’s certificate for the public key (offline)
  - Every computer is pre-configured with CA’s public key

Obtaining a User's Certificate

- Characteristics of certificates generated by CA:
  - Any user with access to the public key of the CA can verify the user public key that was certified.
  - No part other than the CA can modify the certificate without this being detected.

Using Public-Key Certificates



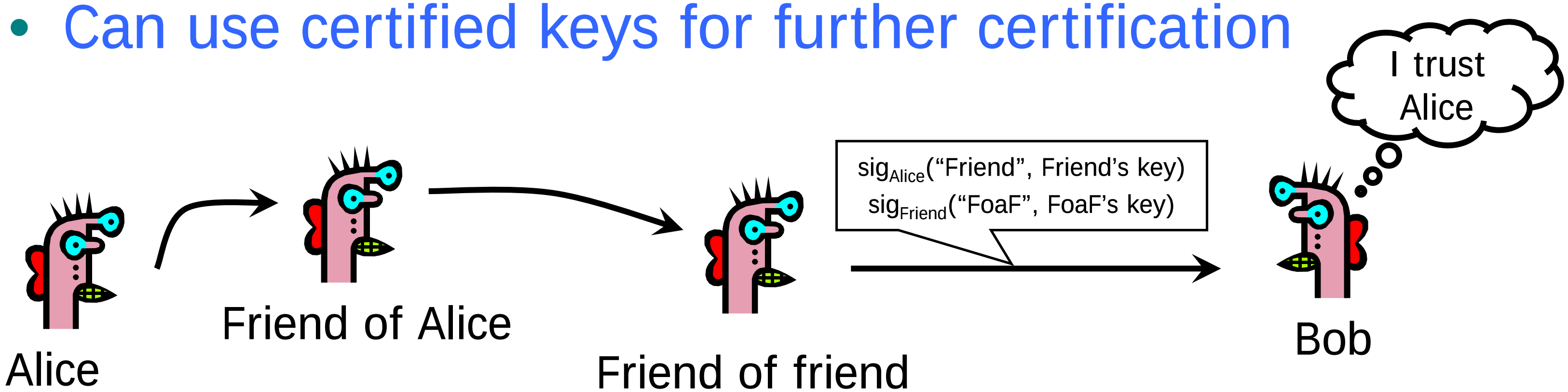
Authenticity of public keys is reduced to authenticity of one key (CA's public key)

Hierarchical Approach

- Single CA certifying every public key is impractical
- Instead, use a trusted root authority
  - For example, Verisign
  - Everybody must know the public key for verifying root authority's signatures
- Root authority signs certificates for lower-level authorities, lower-level authorities sign certificates for individual networks, and so on
  - Instead of a single certificate, use a certificate chain
    - $sig_{Verisign}$("UT Austin", PK_{UT}), sig_{UT}("Vitaly S.", PK_{V})
  - What happens if root authority is ever compromised?

Alternative: "Web of Trust"

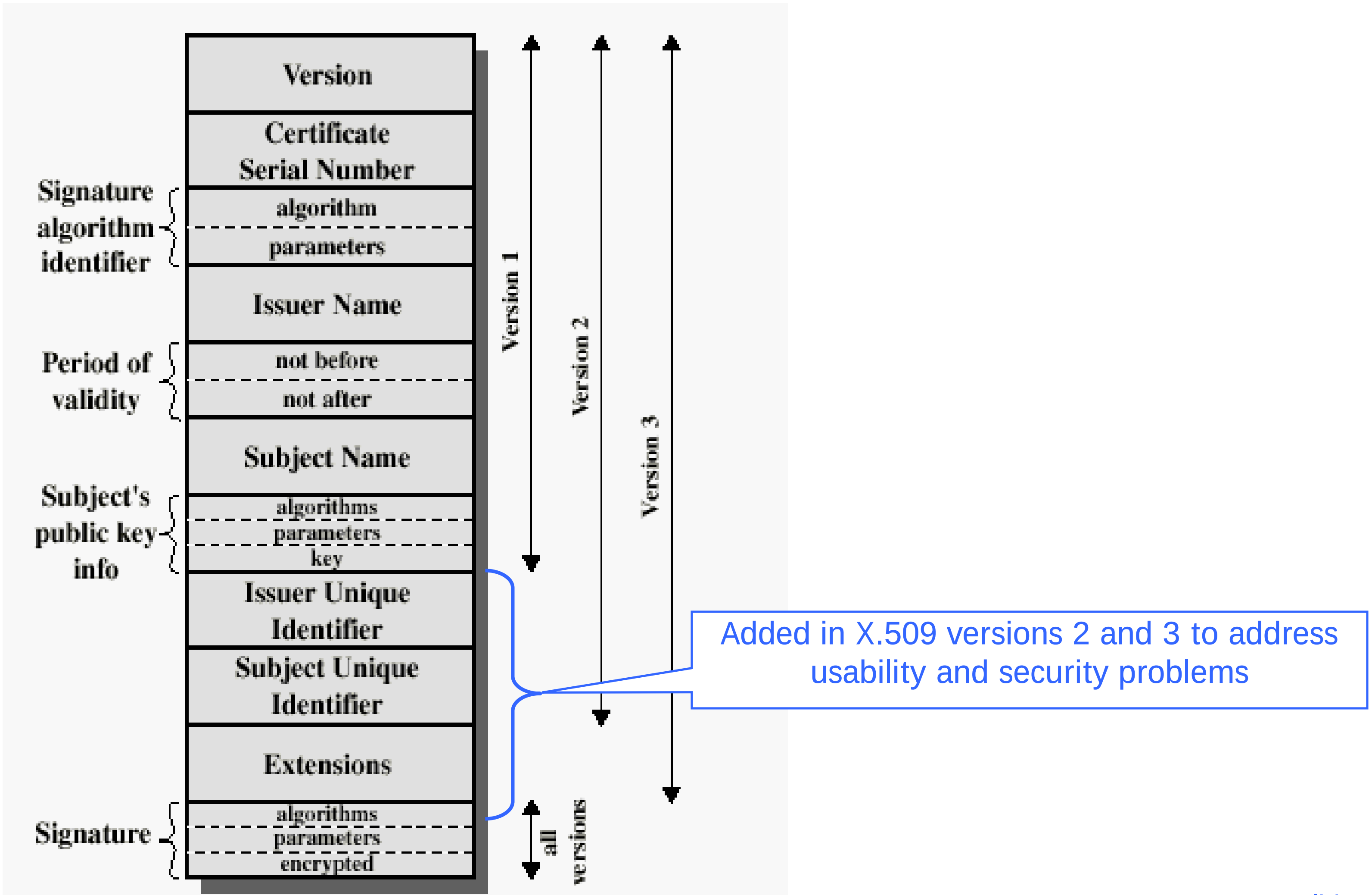
- Used in PGP (Pretty Good Privacy)
- Instead of a single root certificate authority, each person has a set of keys they "trust"
  - If public-key certificate is signed by one of the "trusted" keys, the public key contained in it will be deemed valid
- Trust can be transitive
  - Can use certified keys for further certification



X.509 Authentication Service

- Internet standard (1988-2000)
- Specifies certificate format
  - X.509 certificates are used in IPSec and SSL/TLS
- Specifies certificate directory service
  - For retrieving other users' CA-certified public keys
- Specifies a set of authentication protocols
  - For proving identity using public-key signatures
- Does not specify crypto algorithms
  - Can use it with any digital signature scheme and hash function, but hashing is required before signing

X.509 Certificate



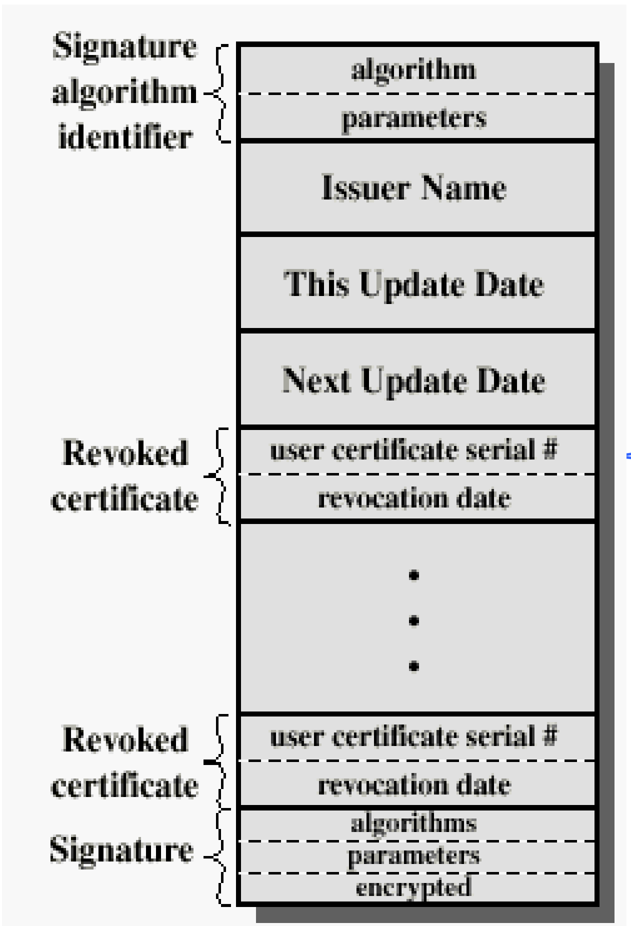
Certificate Revocation

- Revocation is <u>very</u> important
- Many valid reasons to revoke a certificate
  - Private key corresponding to the certified public key has been compromised
  - User stopped paying his certification fee to this CA and CA no longer wishes to certify him
  - CA's certificate has been compromised!
- Expiration is a form of revocation, too
  - Many deployed systems don't bother with revocation
  - Re-issuance of certificates is a big revenue source for certificate authorities

Certificate Revocation Mechanisms

- Online revocation service
  - When a certificate is presented, recipient goes to a special online service to verify whether it is still valid
    - Like a merchant dialing up the credit card processor
- Certificate revocation list (CRL)
  - CA periodically issues a signed list of revoked certificates
    - Credit card companies used to issue thick books of canceled credit card numbers
  - Can issue a “delta CRL” containing only updates
- Question: does revocation protect against forged certificates?

X.509 Certificate Revocation List

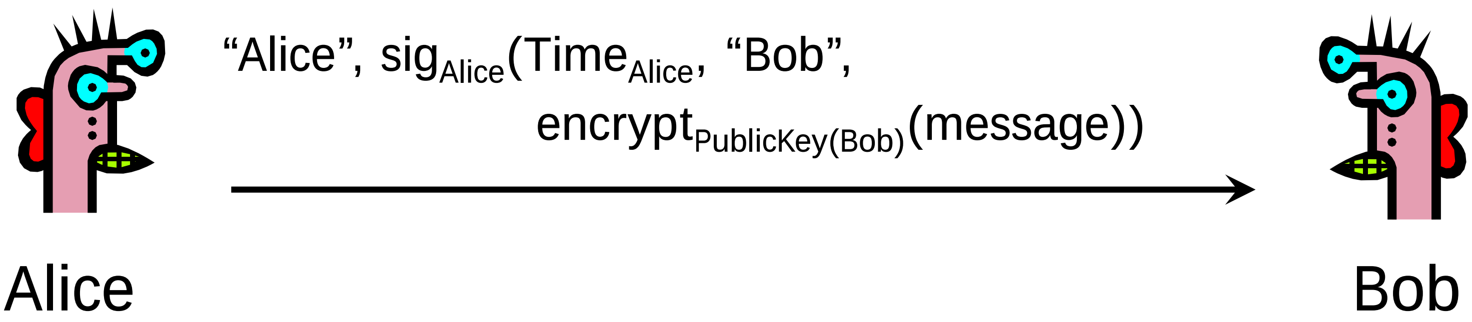


Because certificate serial numbers must be unique within each CA, this is enough to identify the certificate

Online Certificate Status Protocol

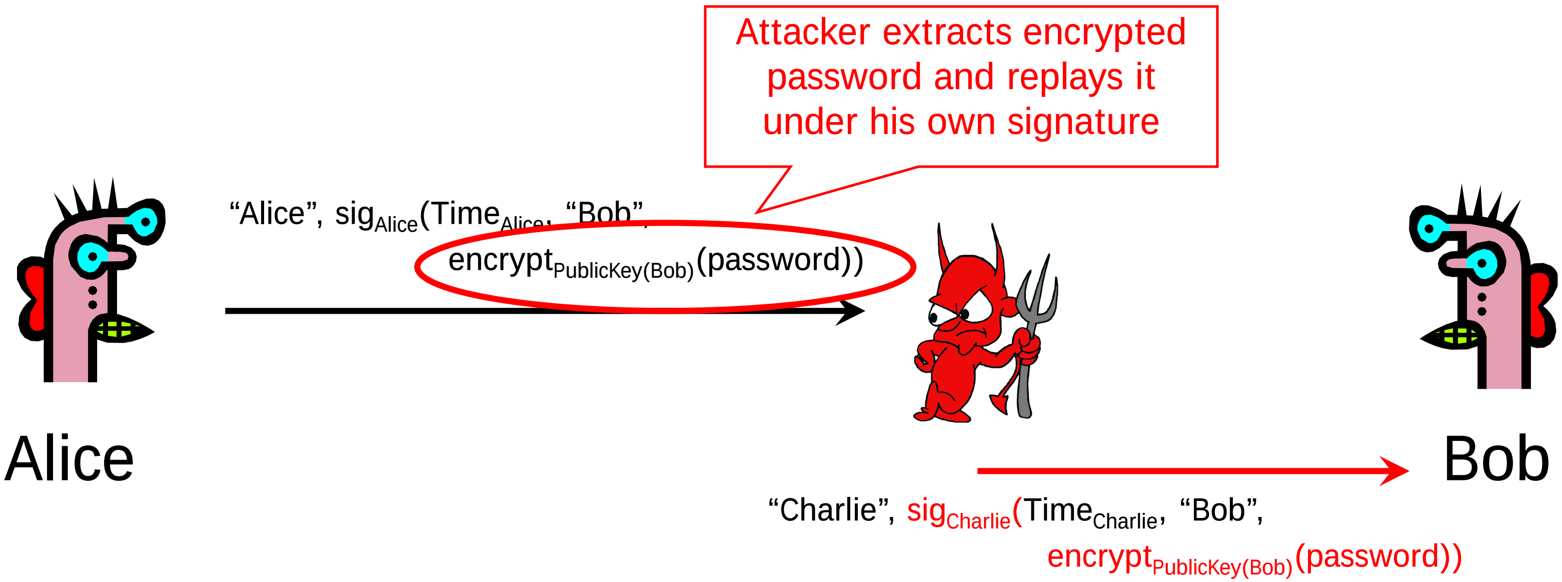
- RFC 2560
  - Saves retrieving the complete CRL
  - OCSP responders could be chained to some degree
    - eg. trusted responder could query other CA's OCSP

X.509 Version 1



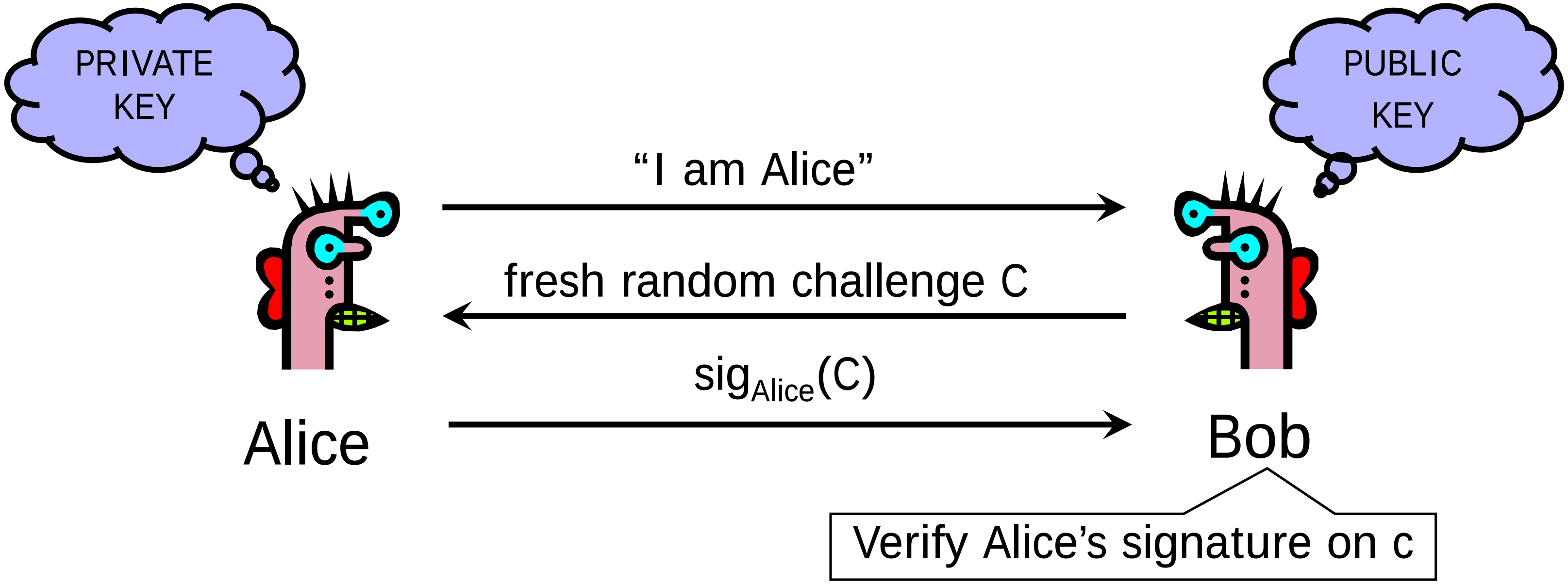
- Encrypt, then sign for authenticated encryption
  - Goal: achieve both confidentiality and authentication
  - E.g., encrypted, signed password for access control
- Does this work?

Attack on X.509 Version 1



- Receiving encrypted password under signature does <u>not</u> mean that the sender actually knows the password!
- Proper usage: sign, then encrypt

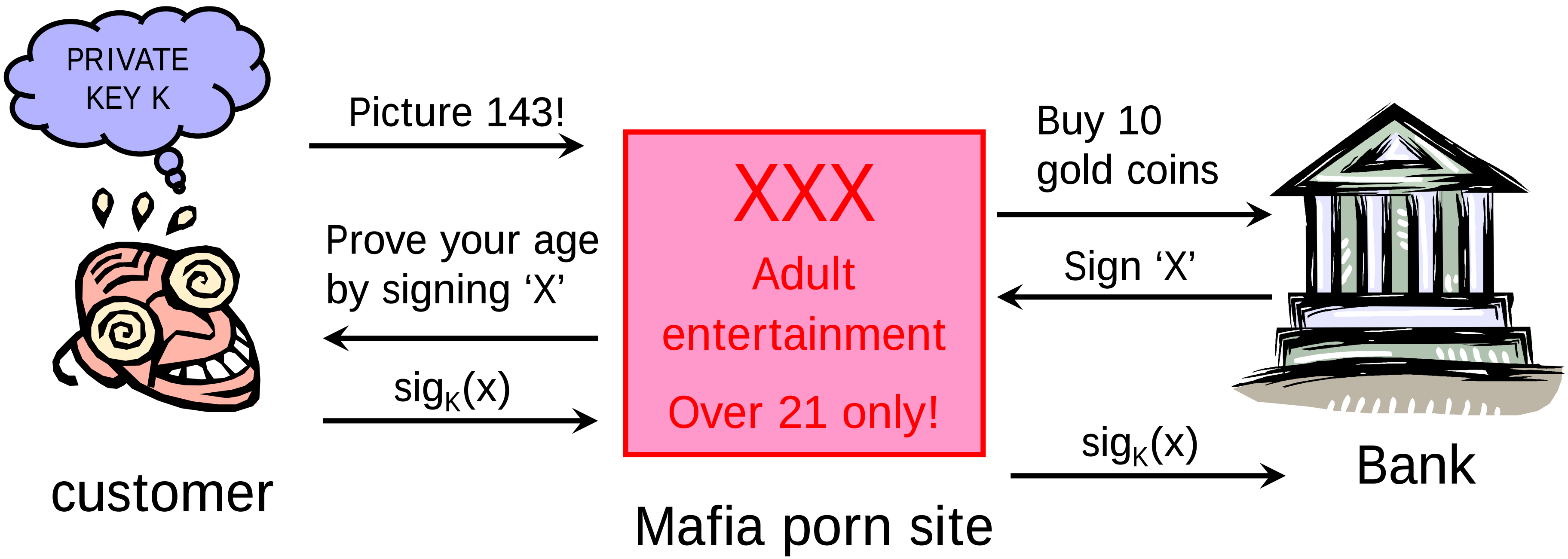
Authentication with Public Keys



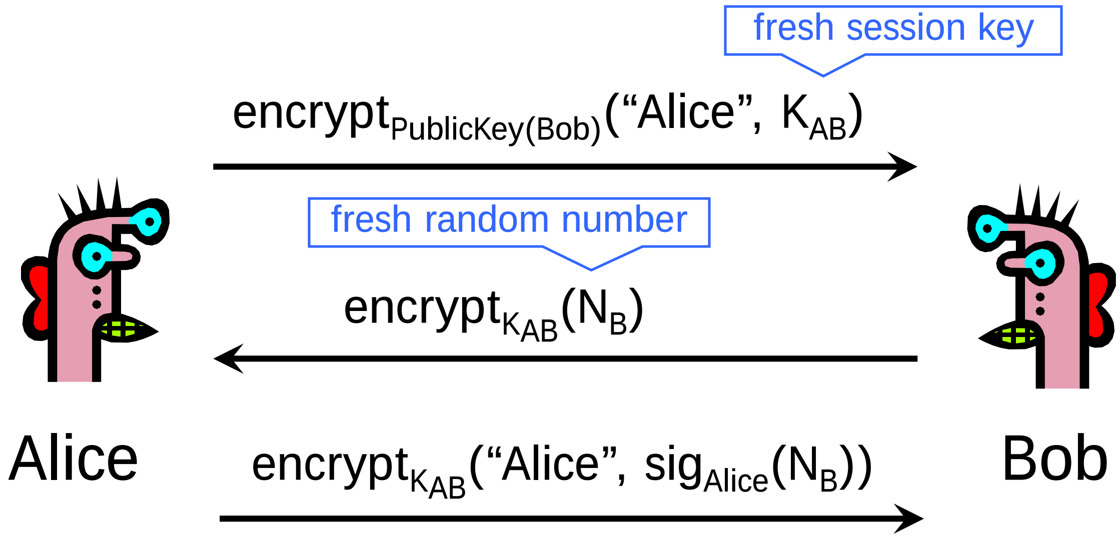
1. Only Alice can create a valid signature
2. Signature is on a fresh, unpredictable challenge

Potential problem: Alice will sign <u>anything</u>

Mafia-in-the-Middle Attack [from Anderson's book]

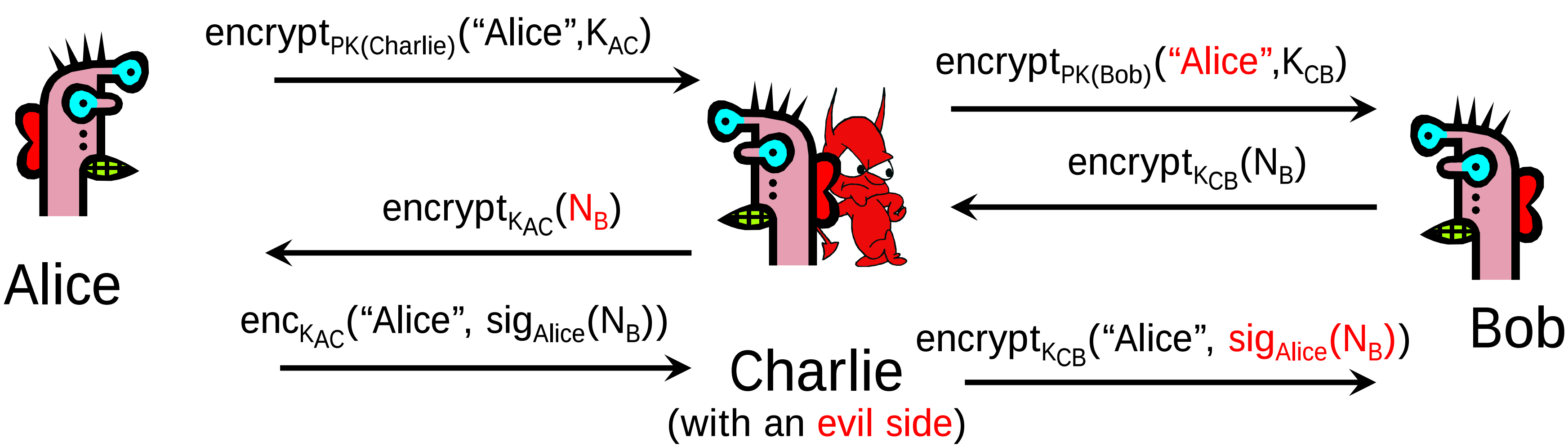


Early Version of SSL (Simplified)



- Bob's reasoning: I must be talking to Alice because...
  - Whoever signed N_B knows Alice's private key... Only Alice knows her private key... Alice must have signed N_B... N_B is fresh and random and I sent it encrypted under K_{AB}... Alice could have learned N_B only if she knows K_{AB}... She must be the person who sent me K_{AB} in the first message...

Breaking Early SSL



- Charlie uses his legitimate conversation with Alice to impersonate Alice to Bob
  - Information signed by Alice is not sufficiently explicit

More Litterature

- Wikipedia entry on X.509
  - Contains list of different file formats
- RFC 3280 ”Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile”
- IETF PKIX charter
  - http://www.ietf.org/html.charters/pkix-charter.html
- www.openvalidation.org
  - OCSP validation resources
- www.openca.org
  - Open Source CA and OCSP software