Security

- E. Rescoria, *SSL and TLS: Designing and Building Secure Systems*. Addison-Wesley, 2001.
- Bruce Schneier, *Applied Cryptography*. Wiley, 1996.

Crypto

- Quantum Cryptography!
- Based on computationally infeasible problems
  - factoring products of large primes
  - discrete logarithms
- If P = NP most of this would break!

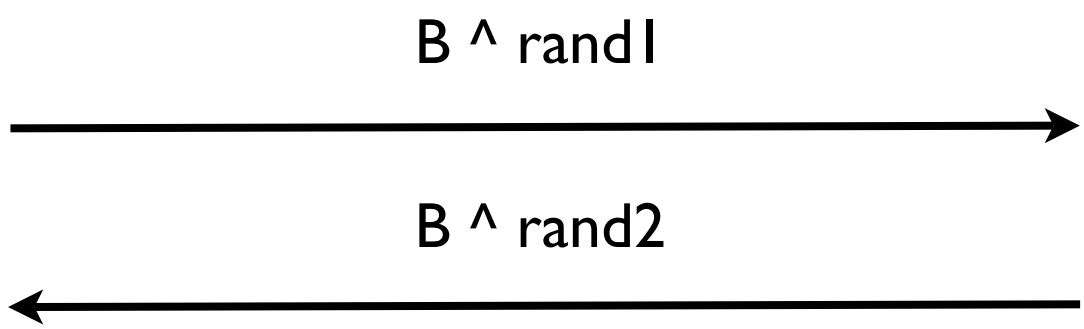
Symmetric Crypto

ciphertext = encrypt(plaintext, key)

plaintext = decrypt(ciphertext, key)

- Same (shared) secret key used for both encryption and decryption
- (same algorithm => bijection)
- DES (and variants like 3-DES) etc.

Diffie-Hellman Key Exchange



k1 = (B ^ rand2) ^ rand1

k2 = (B ^ rand1) ^ rand2

- k1 = k2 computable by either participant
- Eavesdropper cannot compute k
  - (assuming discrete logarithm is difficult)
- Secure channel that is *not* authenticated!

Public Key Crypto

ciphertext = encrypt(plaintext, keya)

plaintext = decrypt(ciphertext, keyb)

- Public/private keys: keya, keyb
- Different keys used for encryption and decryption
- keya public => encryption mode
- keyb public => authentication mode
- RSA, ...
- Key Distribution -- PKI

Hash Function

digest = hash(message)

- Computationally feasible to compute hash of message
- Computationally infeasible to
  - given h, find m such that h = hash(m)
  - find m1, m2 where hash(m1) = hash(m2)
- Computationally cheaper than encryption
- SHA, (MD5)

Digital Signature

signature = encrypt(hash(message), privatekey)

send (message, (signer_id, signature))

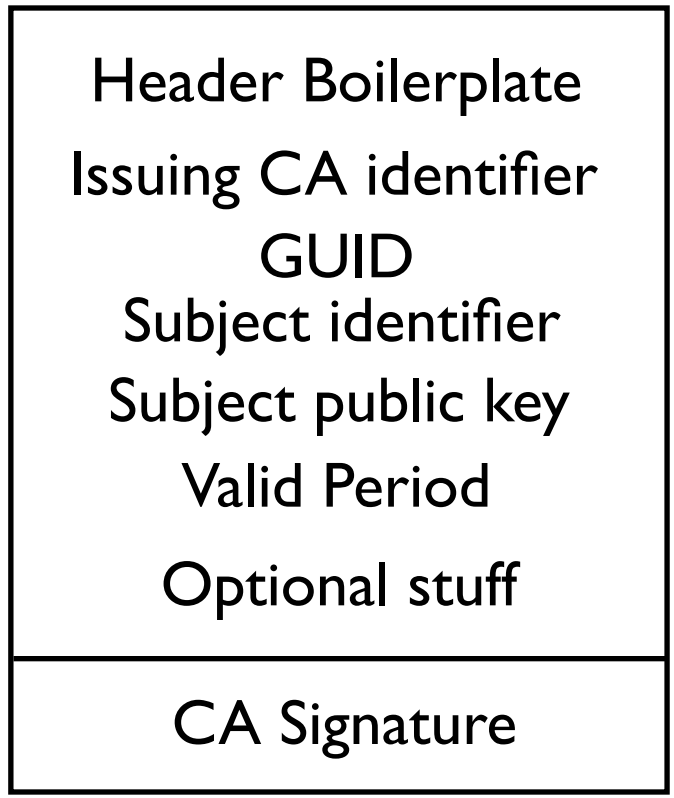
OK = (decrypt(signature, publickey) = hash(message)

- Message is not secret
- Integrity checked
- Non-repudiation

Key Distribution

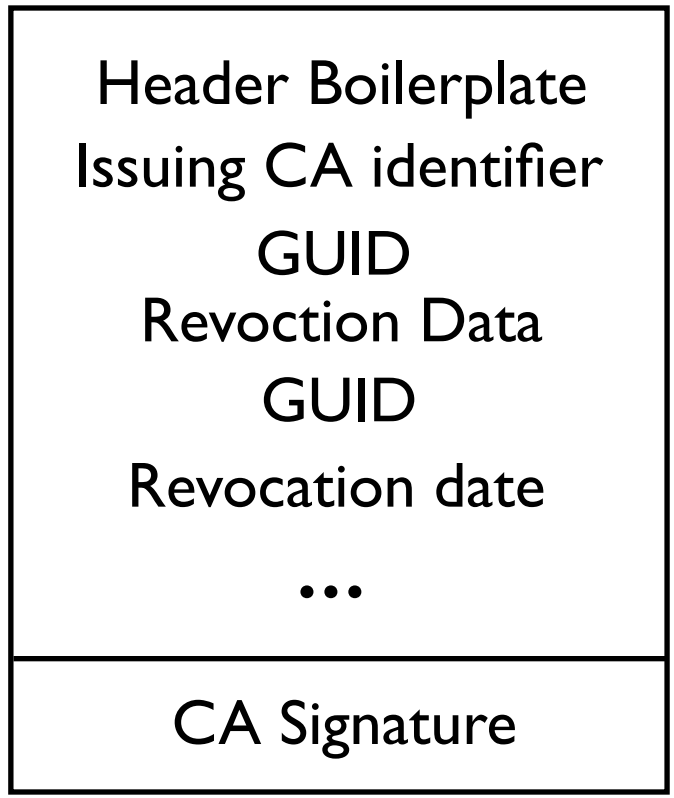
- Why do I believe it is your public key?
  - It's in the New York Times ...
  - But maybe the bad buys have altered my copy of the Times
    - i.e. compromised the key server!
- Certificates!

X.509 Certificate



- Certifying Authority (CA) creates certificate and digitally signs it
- CA public key is well known

Certificate Revocation



- Certifying Authority (CA) creates revocation list and digitally signs it
- CRLs must be made widely available

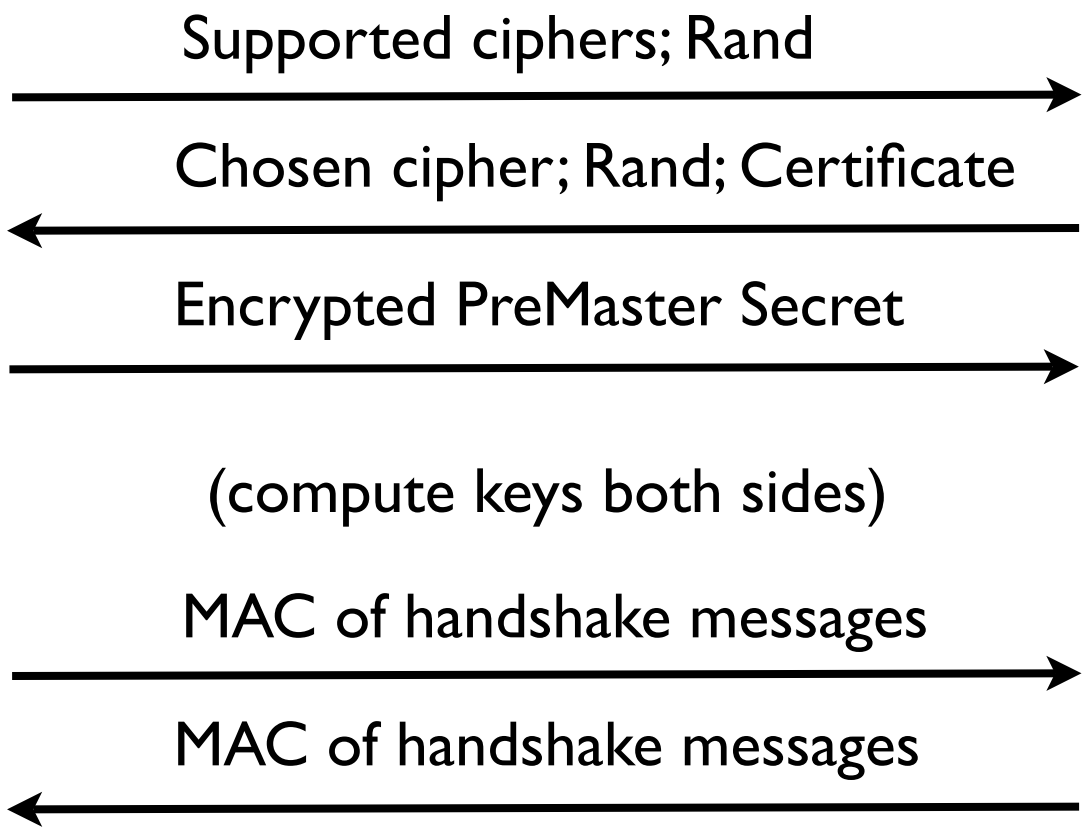
Advanced Features

- Chaining of certificates

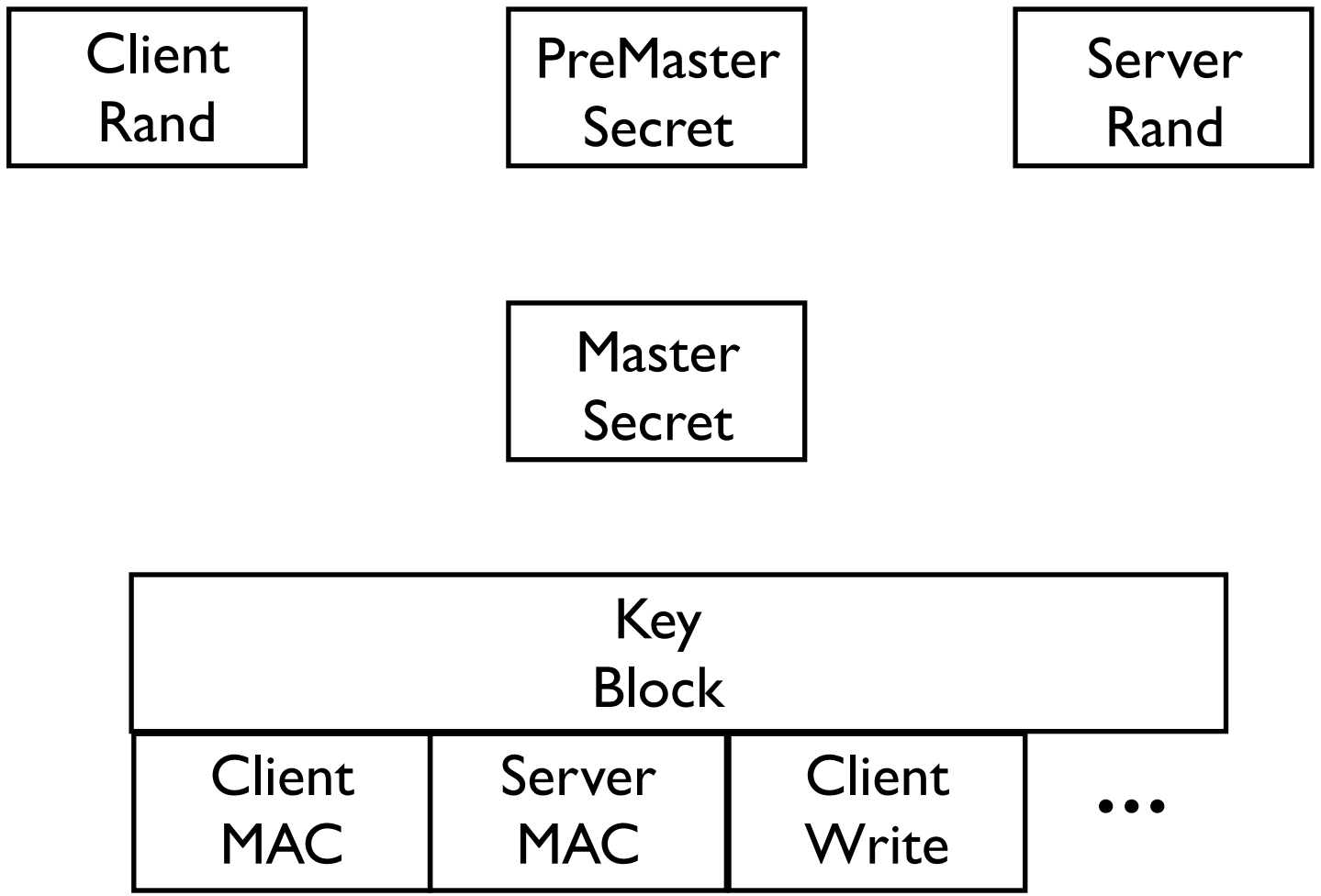
SSL Overview

- Provide authenticated secure channel
  - any TCP application
- Phases:
  - Handshake
    - authenticate
    - establish session key
  - Data Transfer

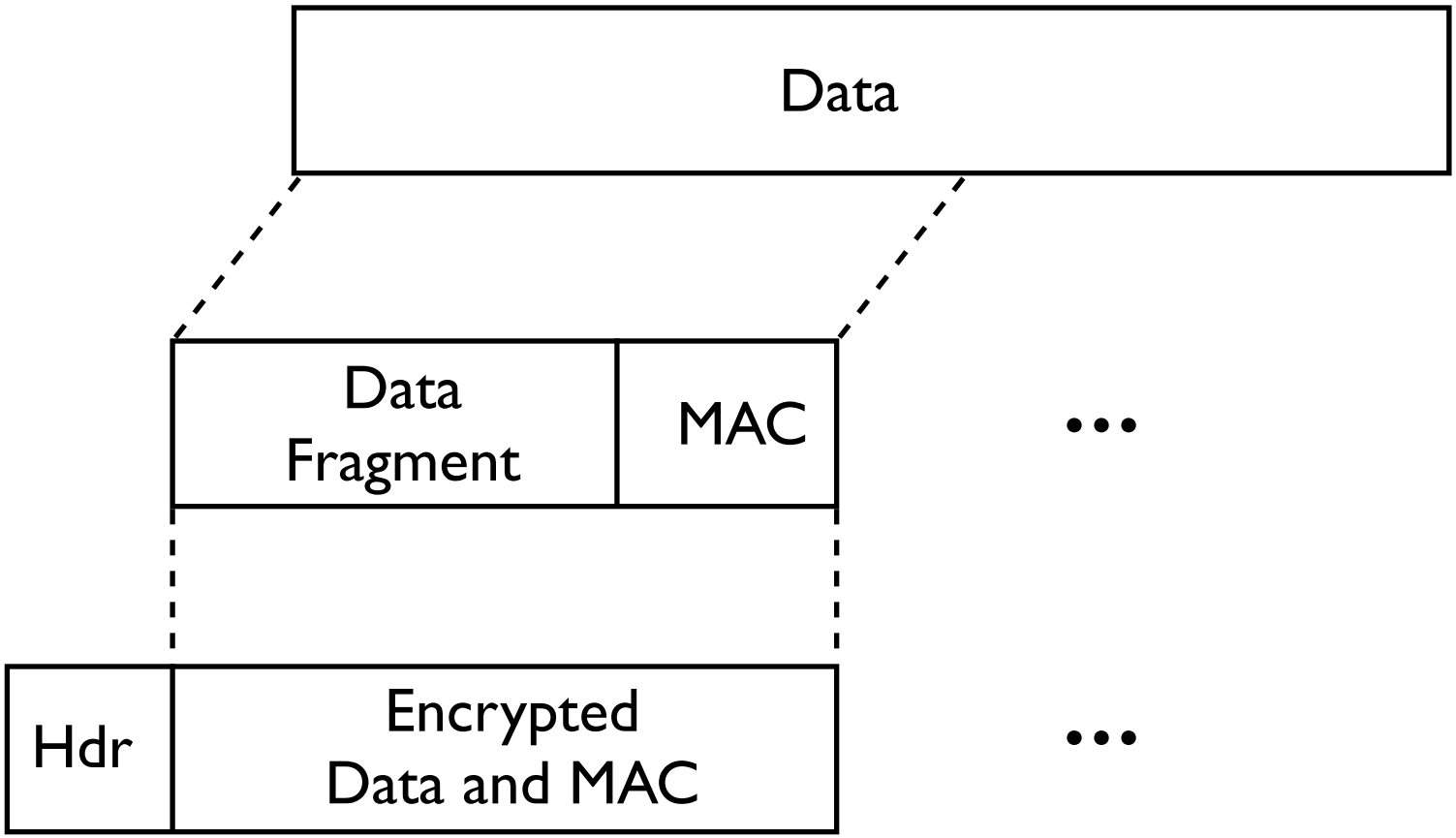
Handshake (Overview)



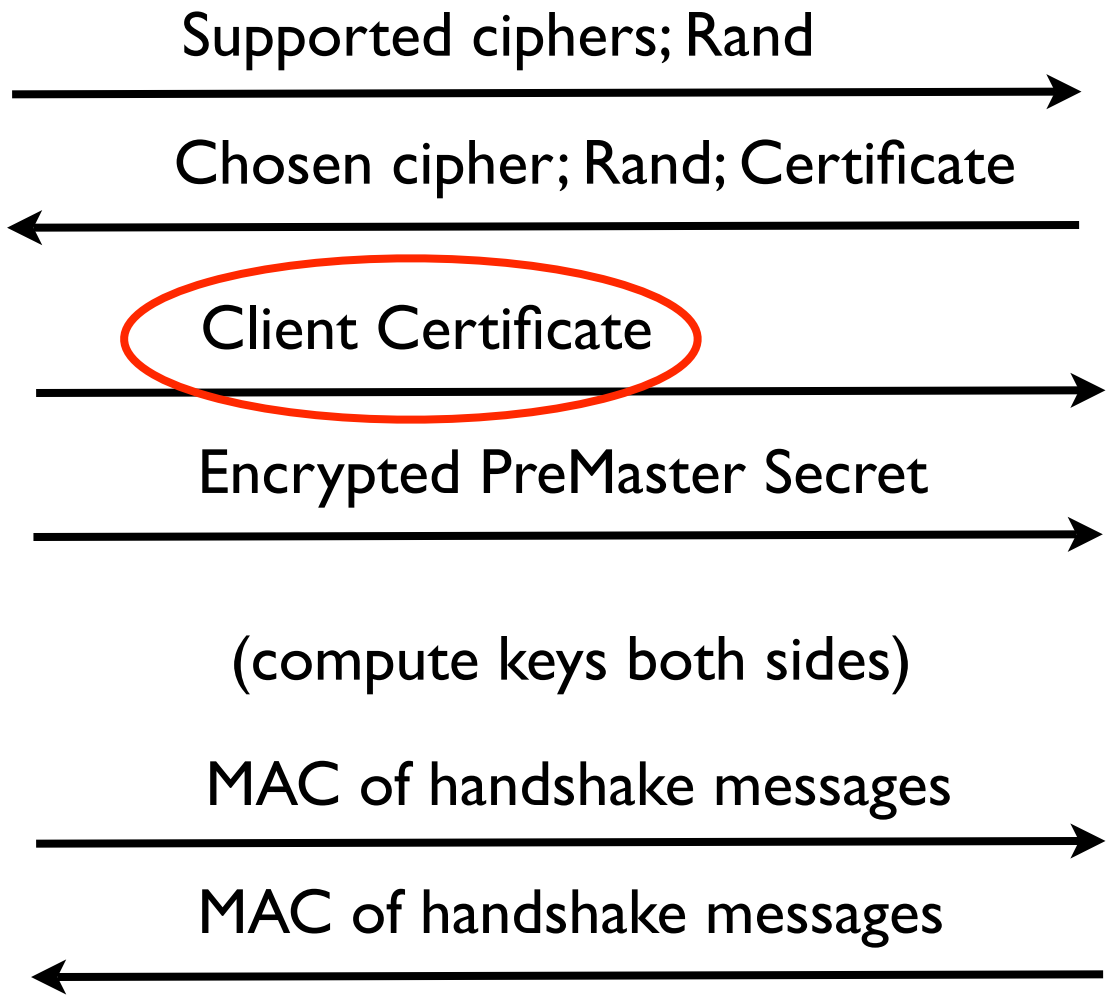
Key Derivation



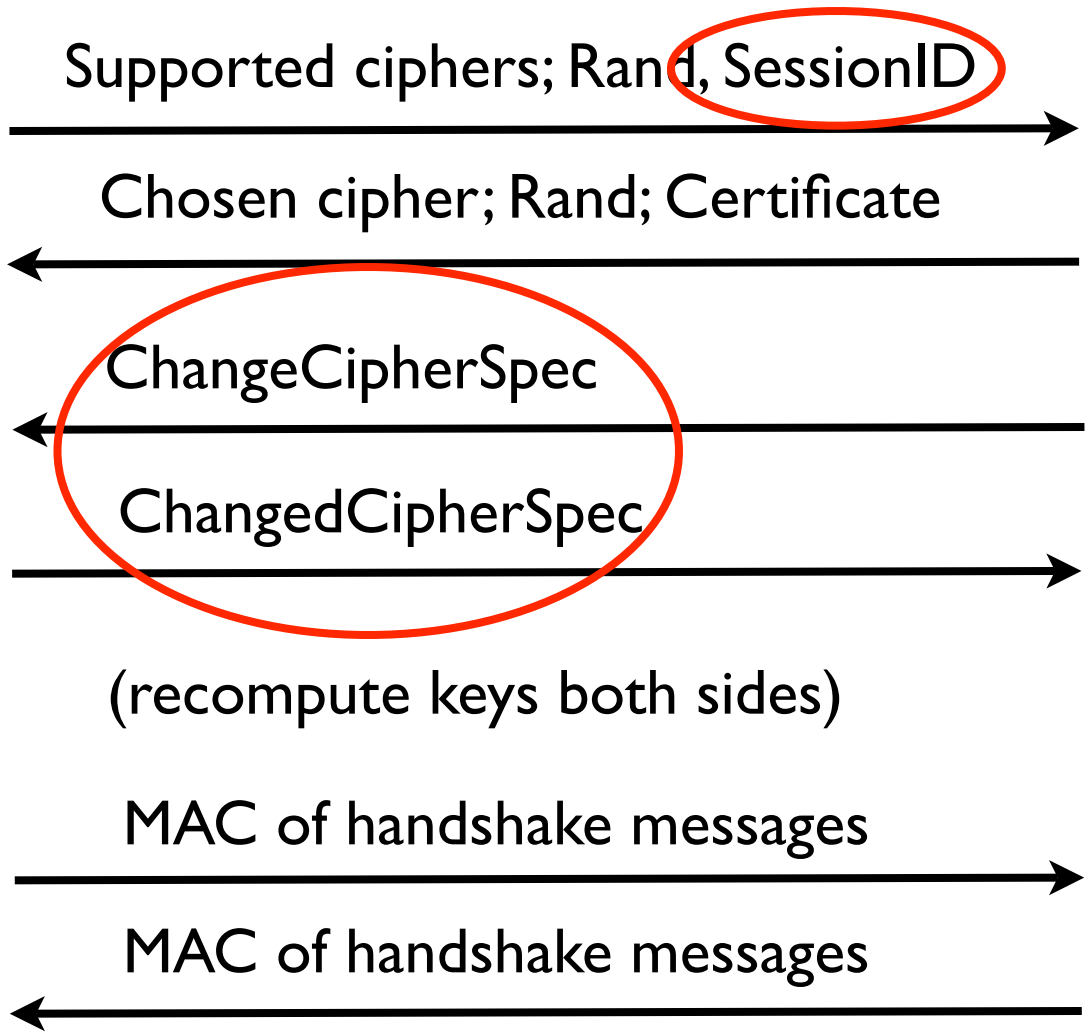
Record Protocol



Client Authentication



Session Resumption



MAC computation requires knowledge of original session master secret!

Choosing SSL

- Port selection
  - http://... uses standard port, unencrypted service
  - https://... SSL capable server on different port
- Negotiation

Password Client Authentication

- Problems:
  - external disclosure
  - guessing
  - eavesdropping
  - replay
  - host compromise

Password Client Authentication

- Problems:
  - external disclosure
    - Stealing it
    - Buying it for chocolate bars
  - guessing
  - eavesdropping
  - replay
  - host compromise

Password Client Authentication

- Problems:
  - external disclosure
  - guessing
    - a very common problem - who can remember all those passwords?
    - (obnoxious) site can require long non-word patterns
  - eavesdropping
  - replay
  - host compromise

Password Client Authentication

- Problems:
  - external disclosure
  - guessing
  - eavesdropping
  - replay
    - SSL is supposed to take care of these
  - host compromise

Password Client Authentication

- Problems:
  - external disclosure
  - guessing
  - eavesdropping
  - replay
  - host compromise
    - do what you can ...

Host Compromise

- User has same password at multiple sites
- DO NOT store passwords anywhere
  - not even encrypted!
- Use a one-way hash function
- Keep (encrypted) hashes in the database
- forgotten password requires reset

Host Compromise

- What about credit card numbers?
- Have to be stored somewhere
- Limit scope of damage?
  - e.g. encrypt with key derived from user password per session
  - (user changes password => credit card number must be re-entered)
- Verisign / PayPal style service
  - At what scale is this sensible?