CSE 484 / CSE M 584 (Spring 2012)

Protocol Rollback and Network Security

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Goals for Today

- Protocol Rollback Attacks (in SSL)
- Network security

- HW2
- Lab 3
- HW 3 (EC)

What is SSL / TLS?

- Transport Layer Security (TLS) protocol, version 1.2
  - De facto standard for Internet security
  - "The primary goal of the TLS protocol is to provide privacy and data integrity between two communicating applications"
  - In practice, used to protect information transmitted between browsers and Web servers (and mail readers and ...)
  - https://datatracker.ietf.org/wg/tls/
- Based on Secure Sockets Layers (SSL) protocol, version 3.0
  - Same protocol design, different algorithms
- Ubiquitously deployed in commercial Web browsers

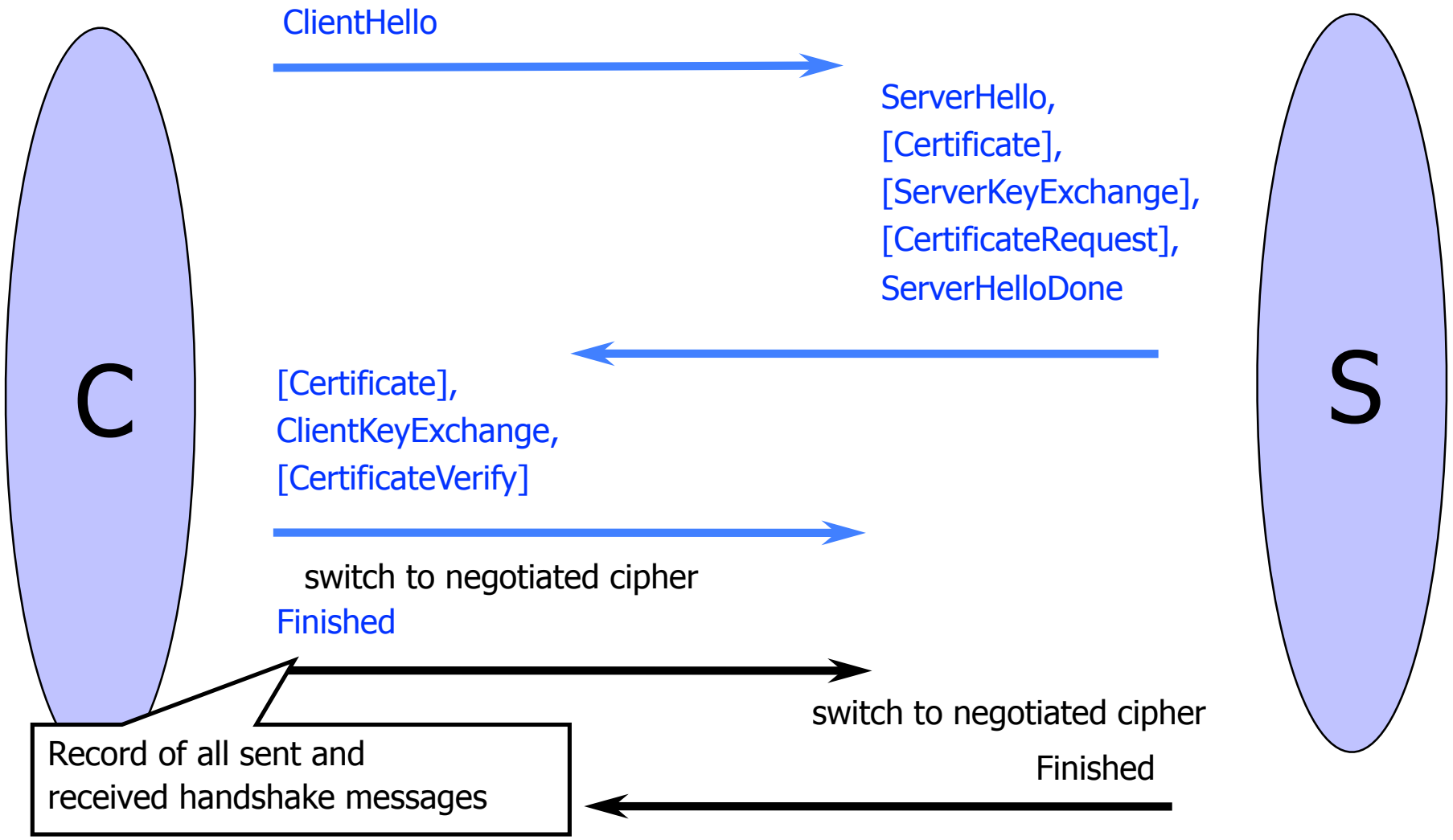
TLS Basics

- TLS consists of two protocols
  - Familiar pattern for key exchange protocols
- Handshake protocol
  - Use public-key cryptography to establish a shared secret key between the client and the server
- Record protocol
  - Use the secret key established in the handshake protocol to protect communication between the client and the server
- We will focus on the handshake protocol

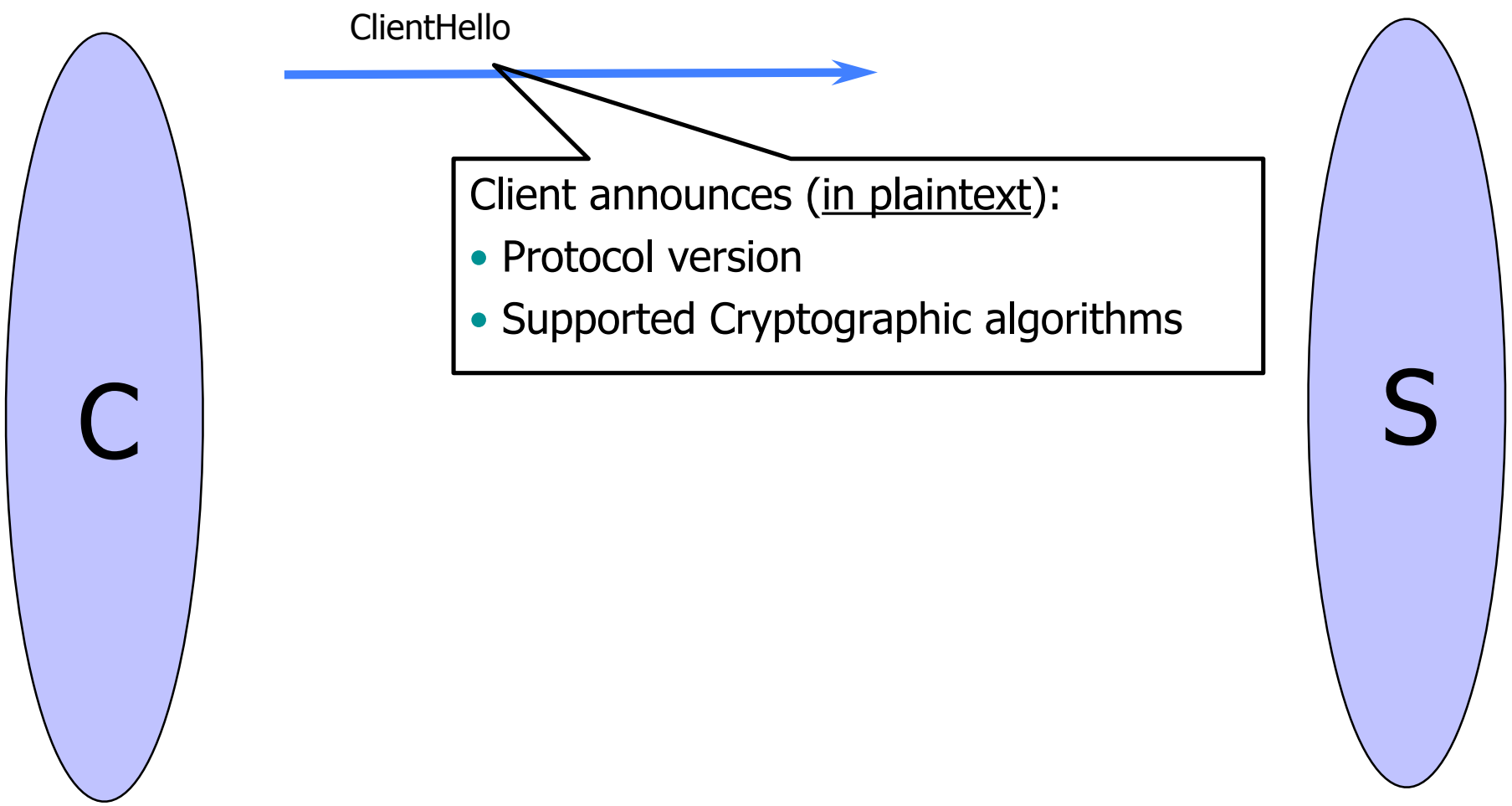
TLS Handshake Protocol

- Two parties: client and server
- Negotiate version of the protocol and the set of cryptographic algorithms to be used
  - Interoperability between different implementations of the protocol
- Authenticate client and server (optional)
  - Use digital certificates to learn each other's public keys and verify each other's identity
- Use public keys to establish a shared secret

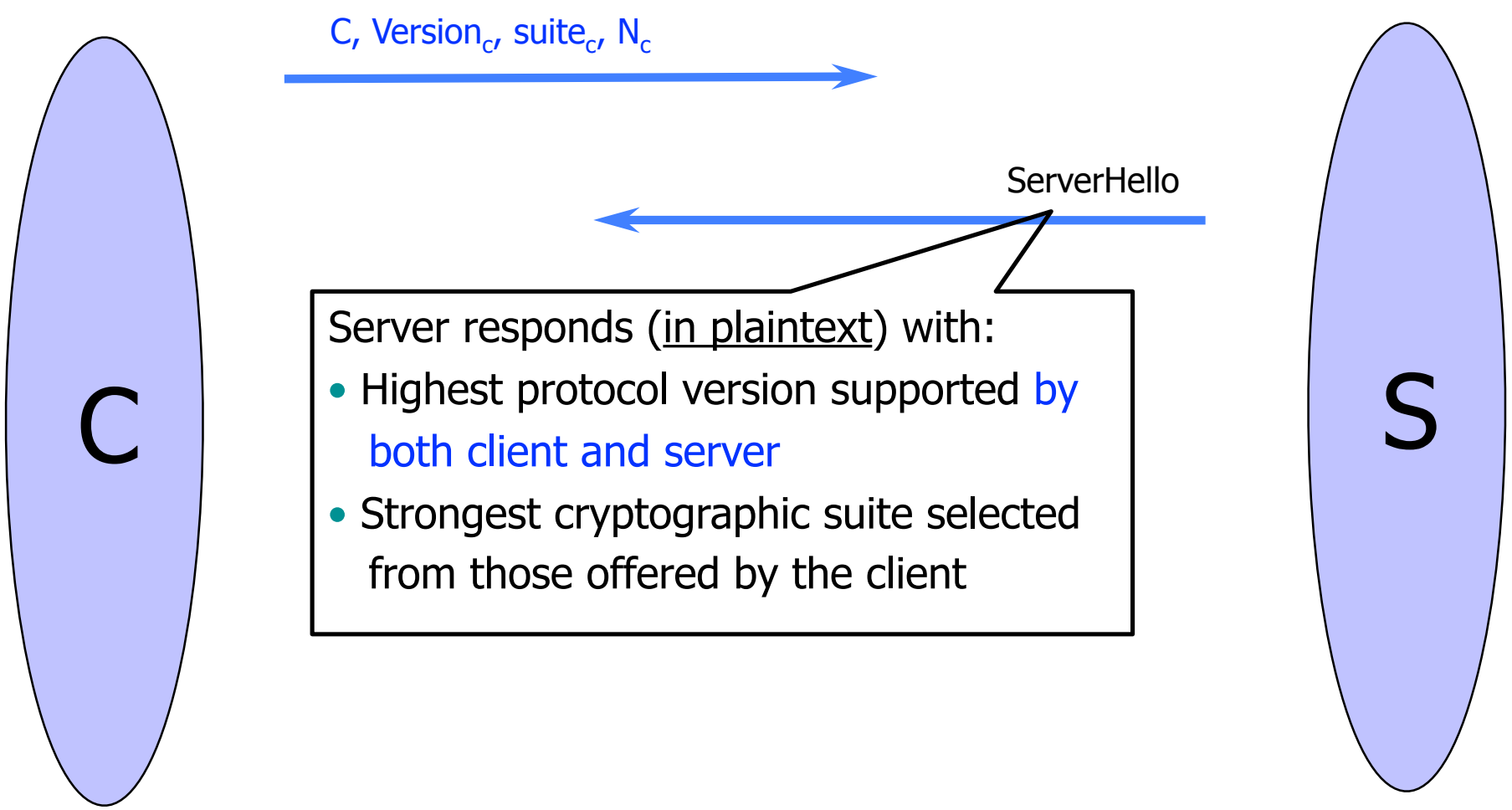
Handshake Protocol Structure



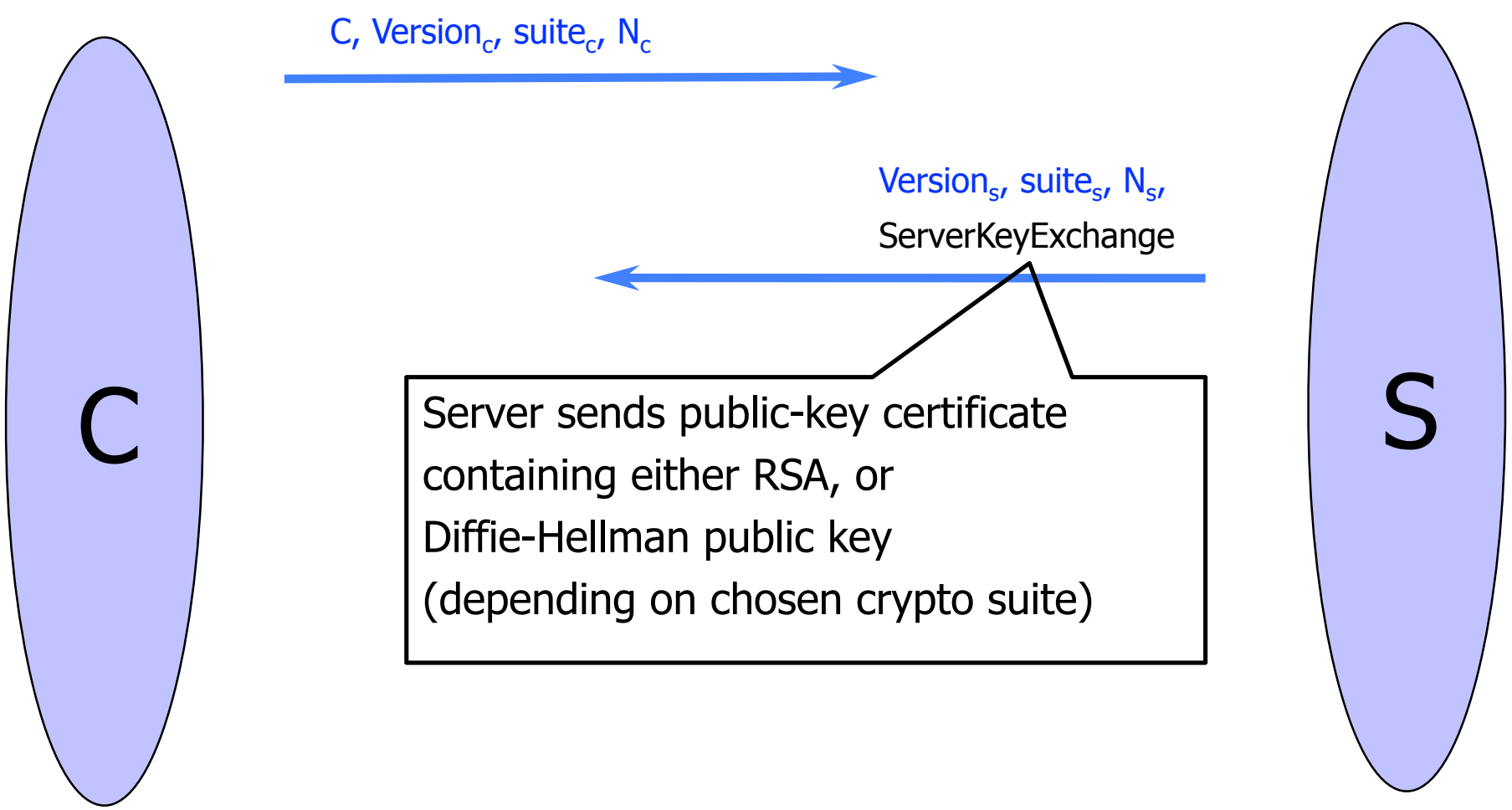
ClientHello



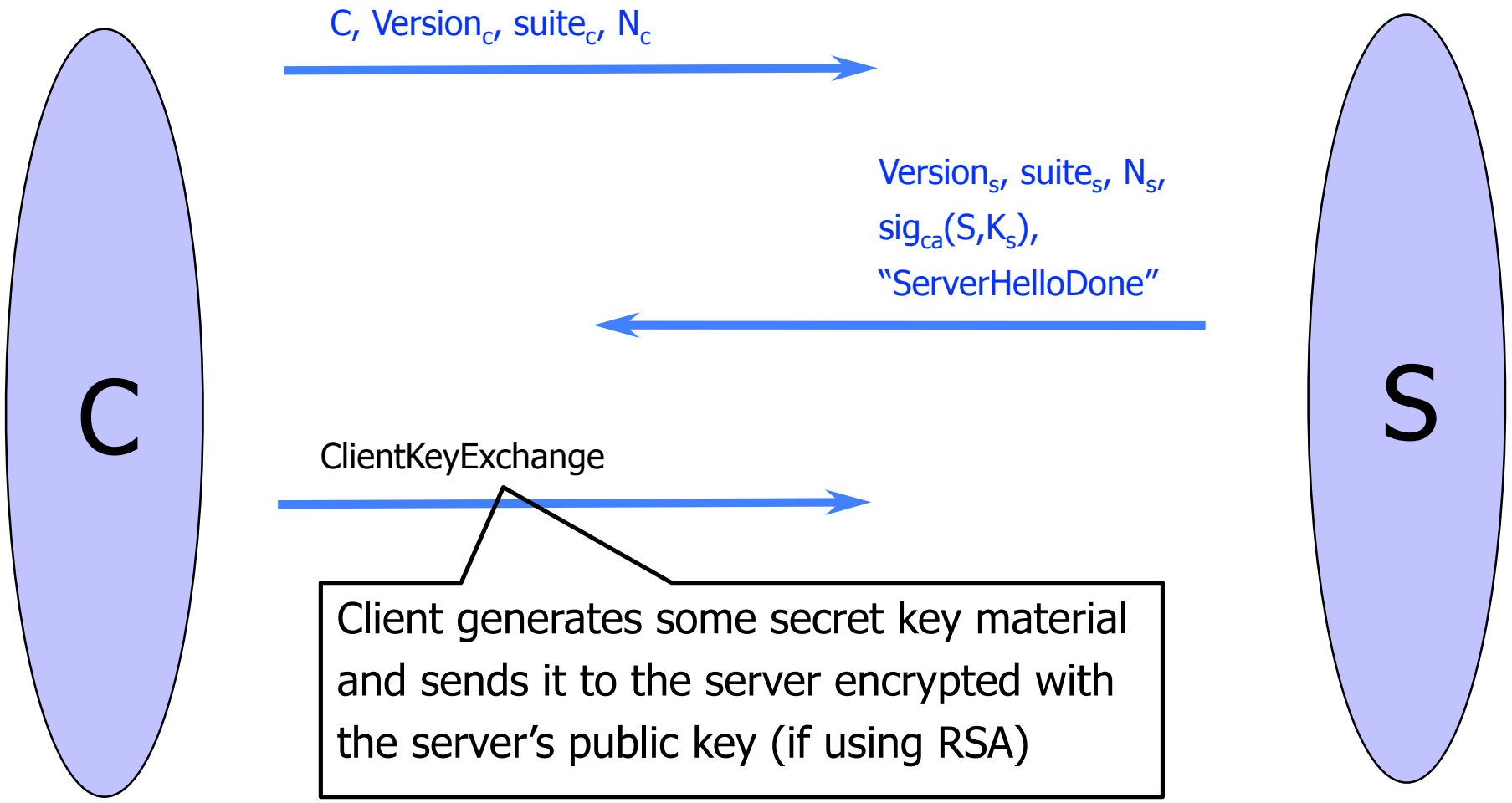
ServerHello



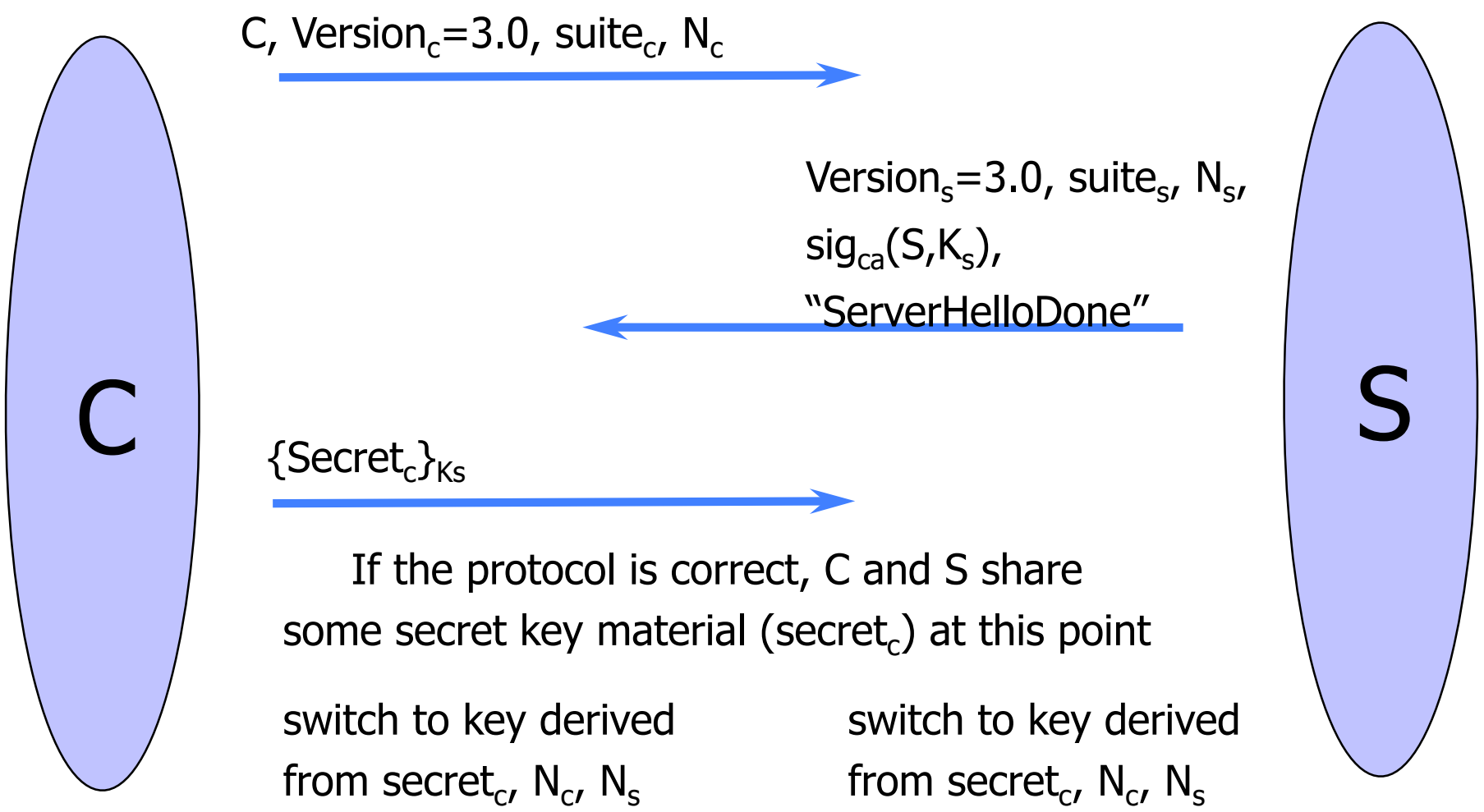
ServerKeyExchange



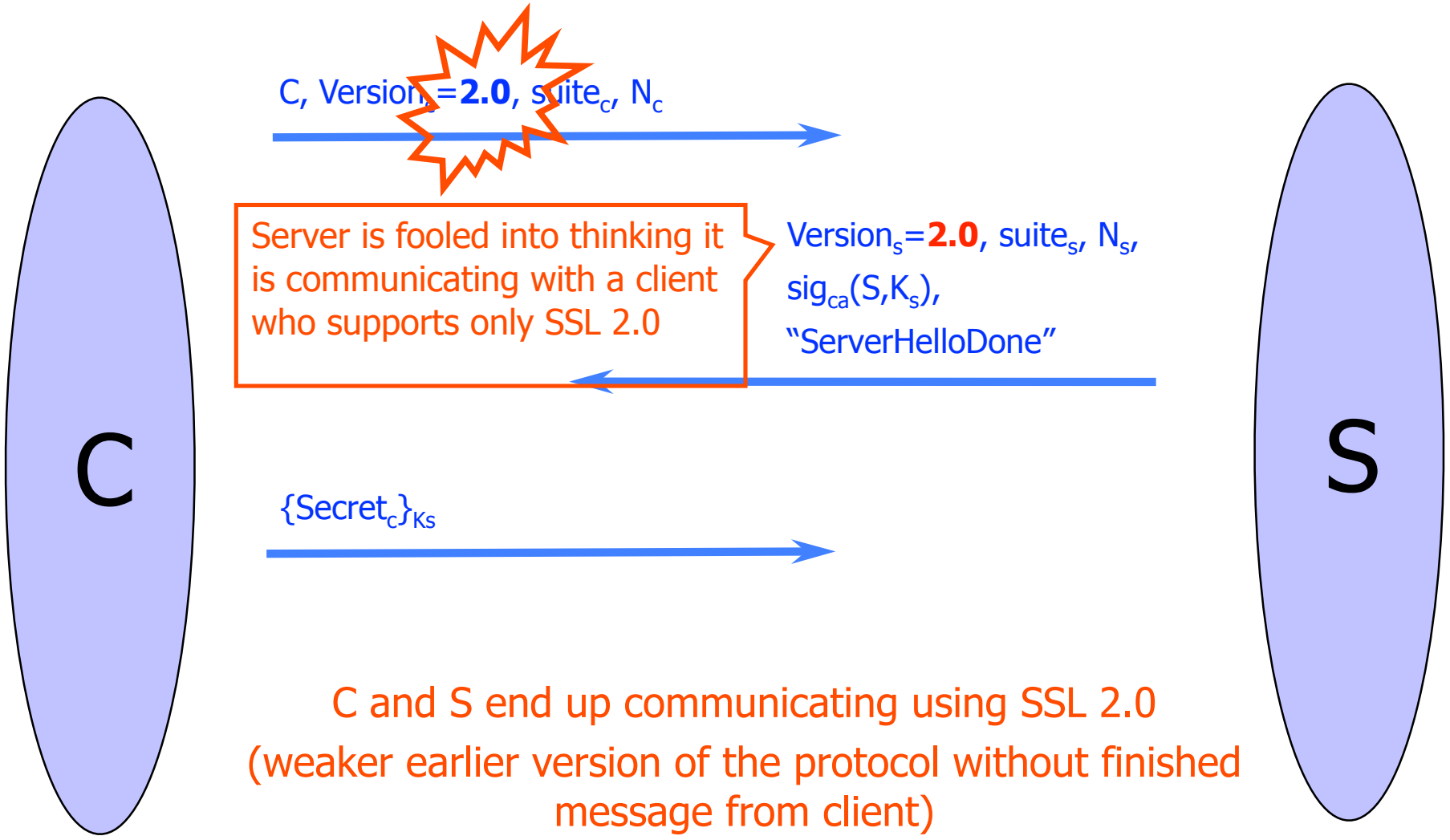
ClientKeyExchange



"Core" SSL 3.0 Handshake (Not TLS)



Version Rollback Attack



C and S end up communicating using SSL 2.0

(weaker earlier version of the protocol without finished message from client)

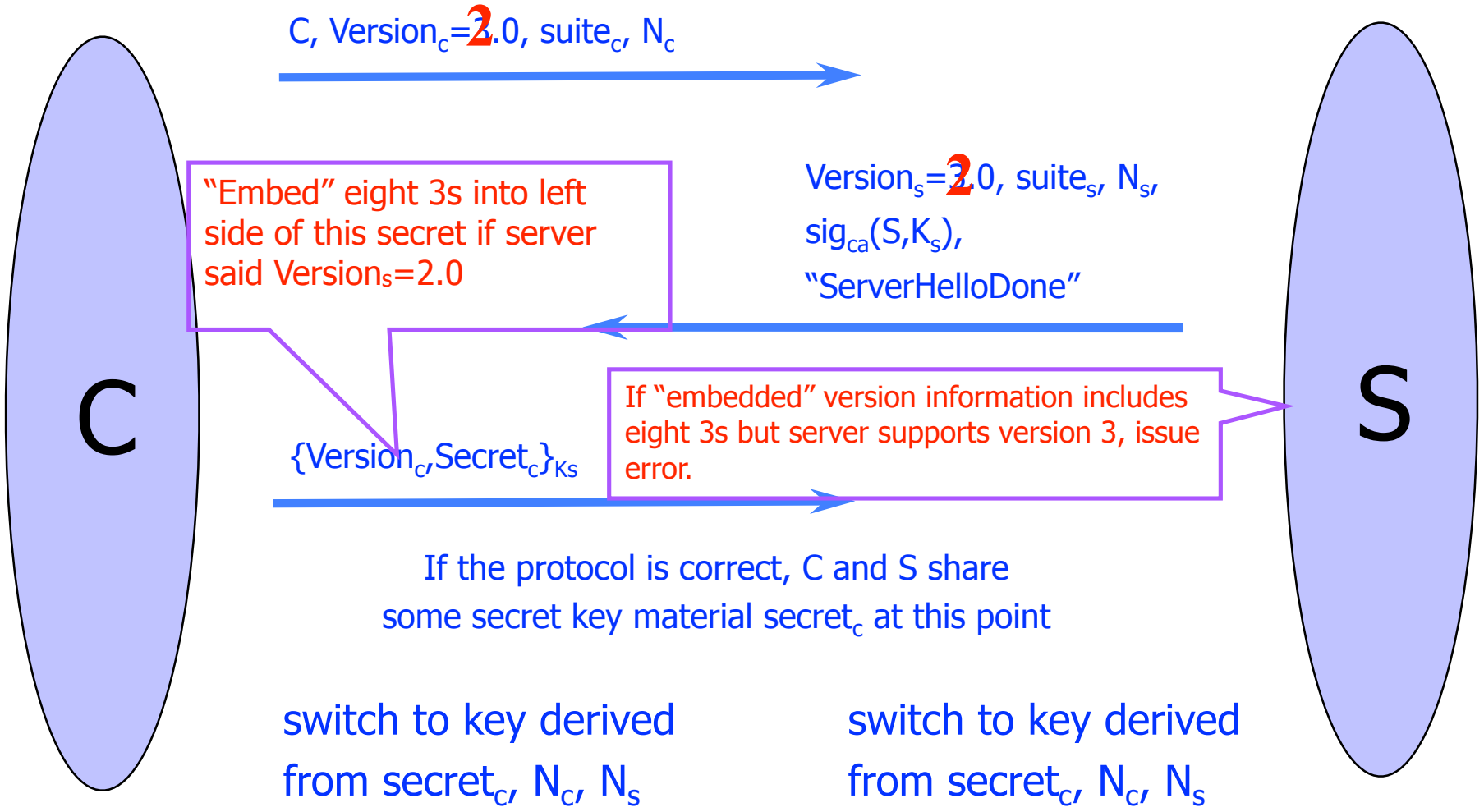
SSL 2.0 Weaknesses (Fixed in 3.0)

- Cipher suite preferences are not authenticated
  - "Cipher suite rollback" attack is possible
- SSL 2.0 uses padding when computing MAC in block cipher modes, but padding length field is not authenticated
  - Attacker can delete bytes from the end of messages
- MAC hash uses only 40 bits in export mode
- No support for certificate chains or non-RSA algorithms, no handshake while session is open

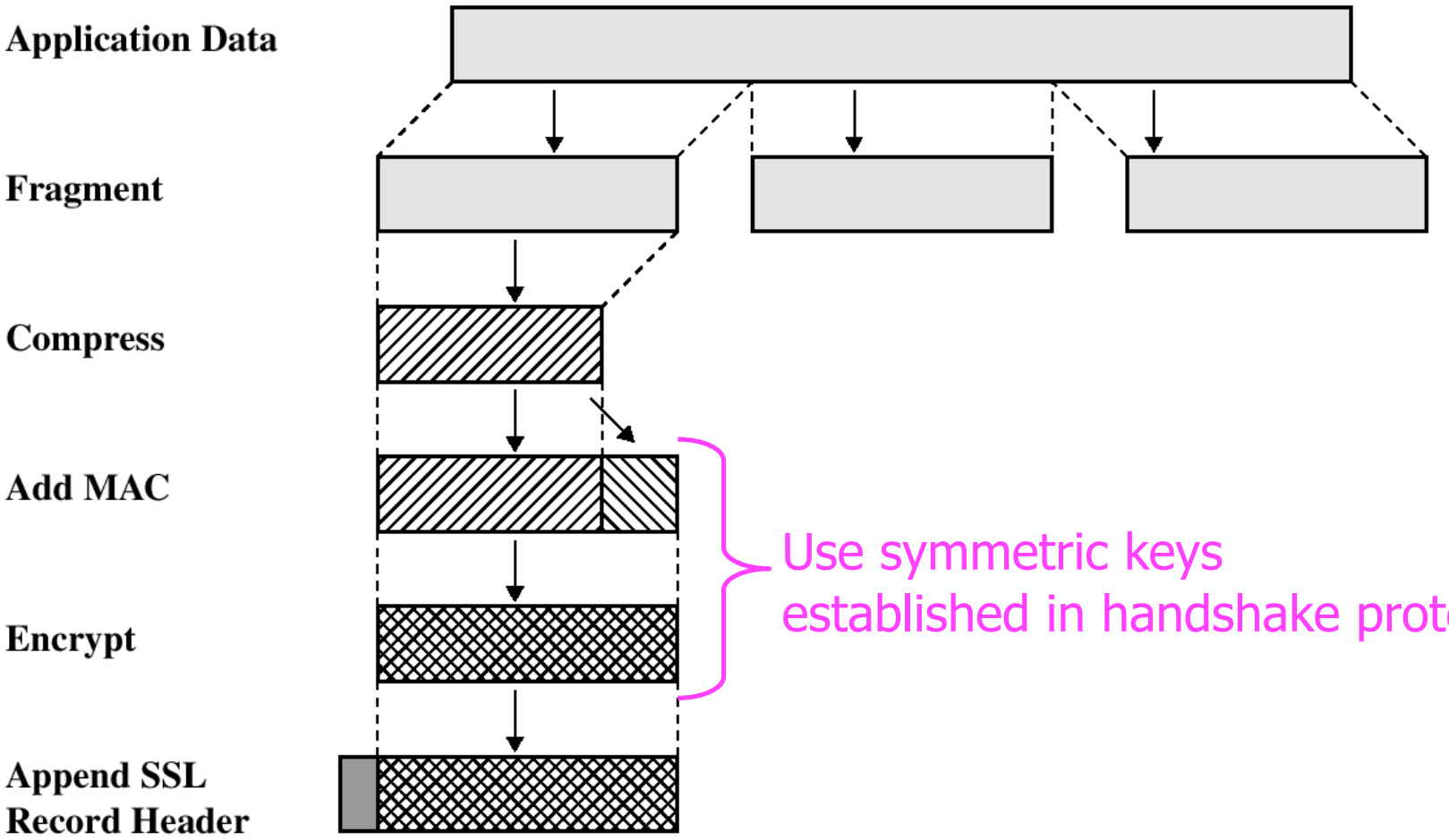
Protocol Rollback Attacks

- Why do people release new versions of security protocols? Because the old version got broken!
- New version must be backward-compatible
  - Not everybody upgrades right away
- Attacker can fool someone into using the old, broken version and exploit known vulnerability
  - Similar: fool victim into using weak crypto algorithms
- Defense is hard: must authenticate version in early designs
- Many protocols had "version rollback" attacks
  - SSL, SSH, GSM (cell phones)

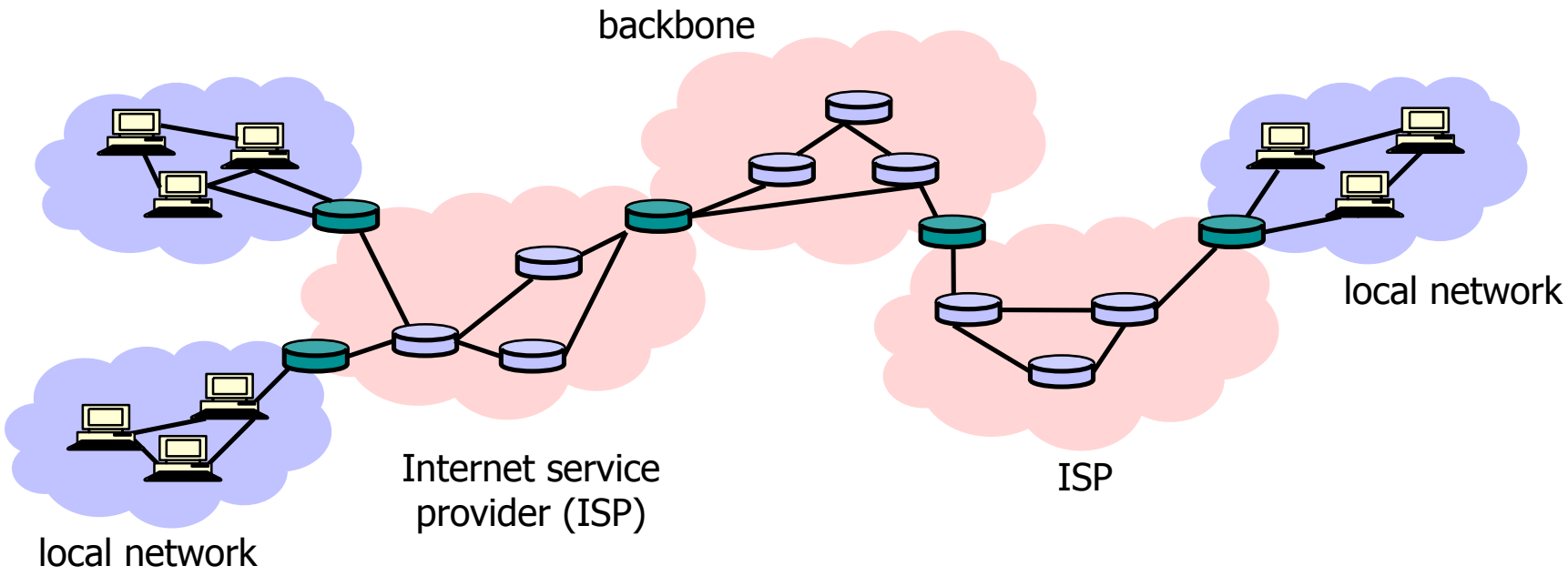
Version Check in SSL 3.0 (Approximate)



SSL/TLS Record Protection

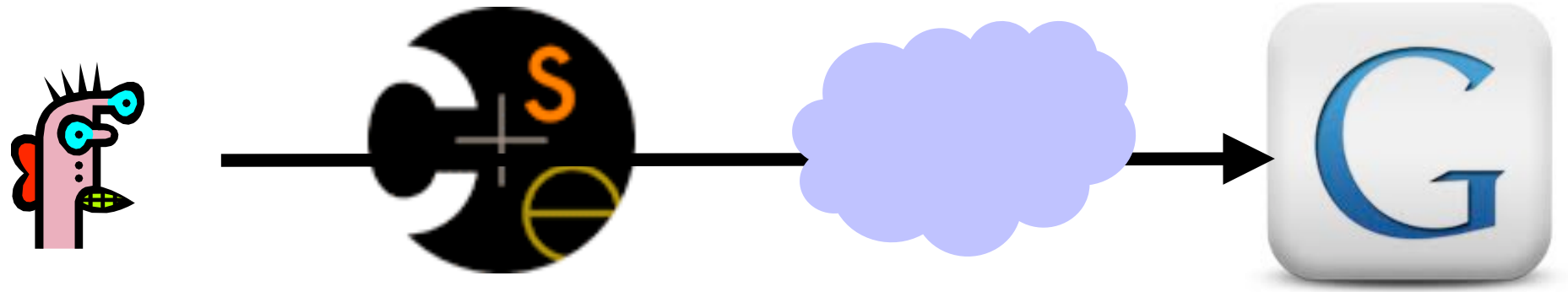


Internet Infrastructure

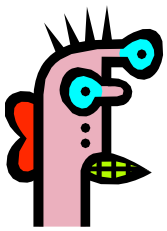


- TCP/IP for packet routing and connections
- Border Gateway Protocol (BGP) for route discovery
- Domain Name System (DNS) for IP address discovery

(Some) Entities



(Some) Goals



User

- Service (can get to Internet)
- Privacy (middle-entities shouldn't know what communicating or with whom)
- Fairness (e.g., get service I paid for)
- Integrity (can't impersonate me, modify my data)
- Safety (network shouldn't attack me)

(Some) Goals

Network Admin

- Service (clients can get to Internet)
- Performance (network works well)
- Identity (know what's on network)
- Safety (no one launching attacks)
- Accountability (can find bad users)

(Some) Goals

Intermediate ISPs

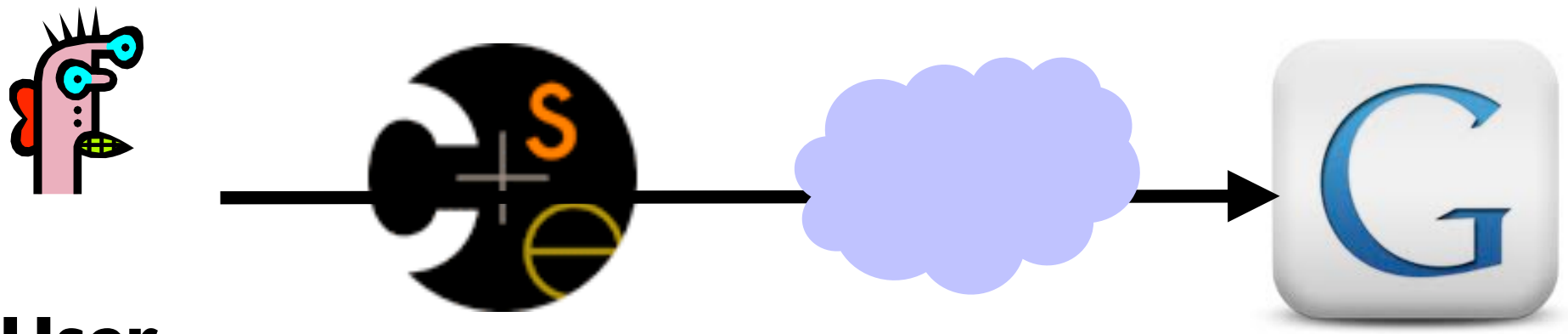
- Service (deliver traffic -> earn $$)
- Reliability & Performance (network works well)
- Integrity of delivered traffic (can bill customers properly, you're not over-charged by providers)

(Some) Goals

Server

- Service (deliver traffic -> earn $$)
- Reliability & Performance (network works well)
- Analytics (better delivery)
- Accounting (can bill customers properly)
- Safety (not being attacked)

(Some) Malicious Goals



User

Network Admin

Intermediate ISPs

Server

Launch undetectable attacks

Probe for vulnerabilities

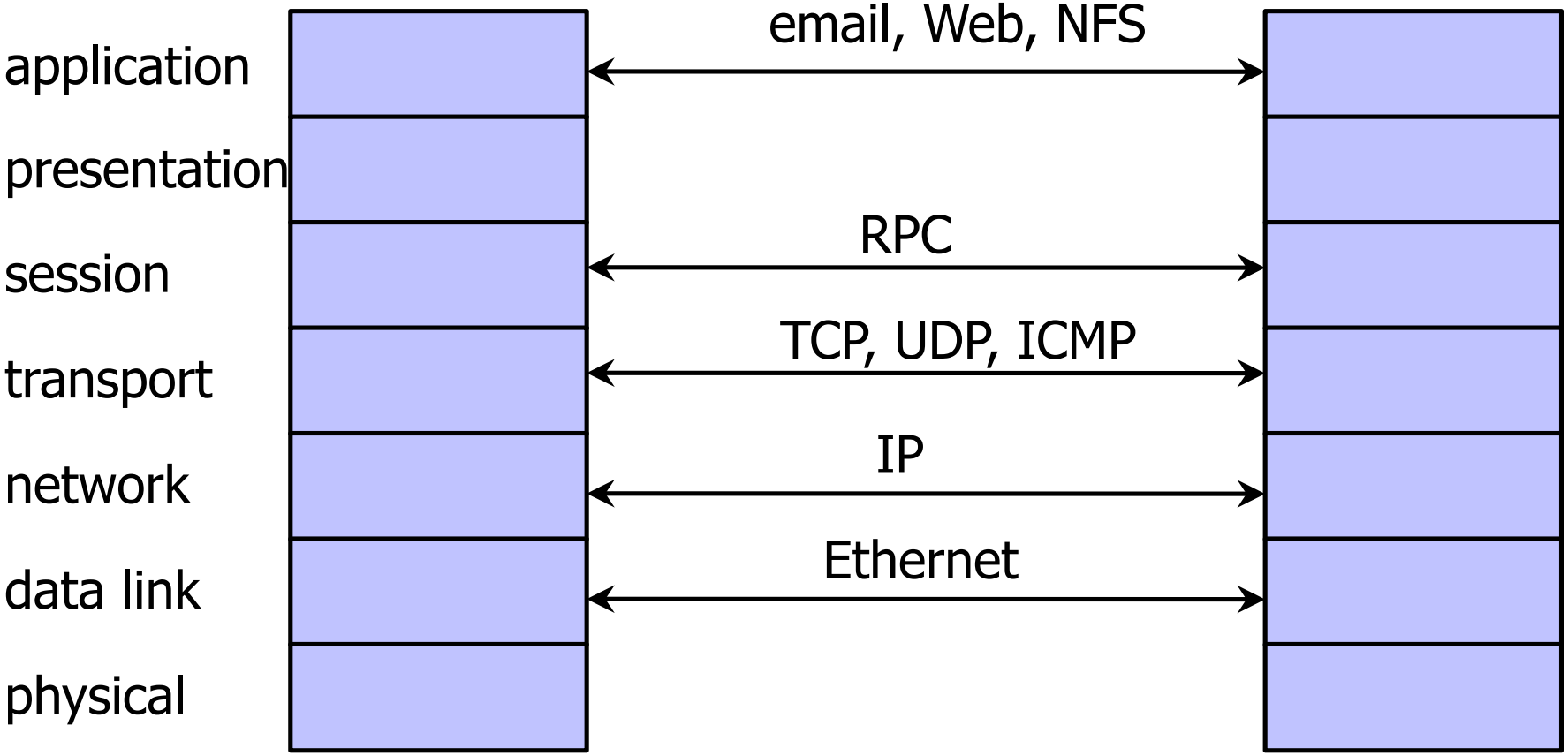
Spy on/tamper with traffic

Impersonate servers/users

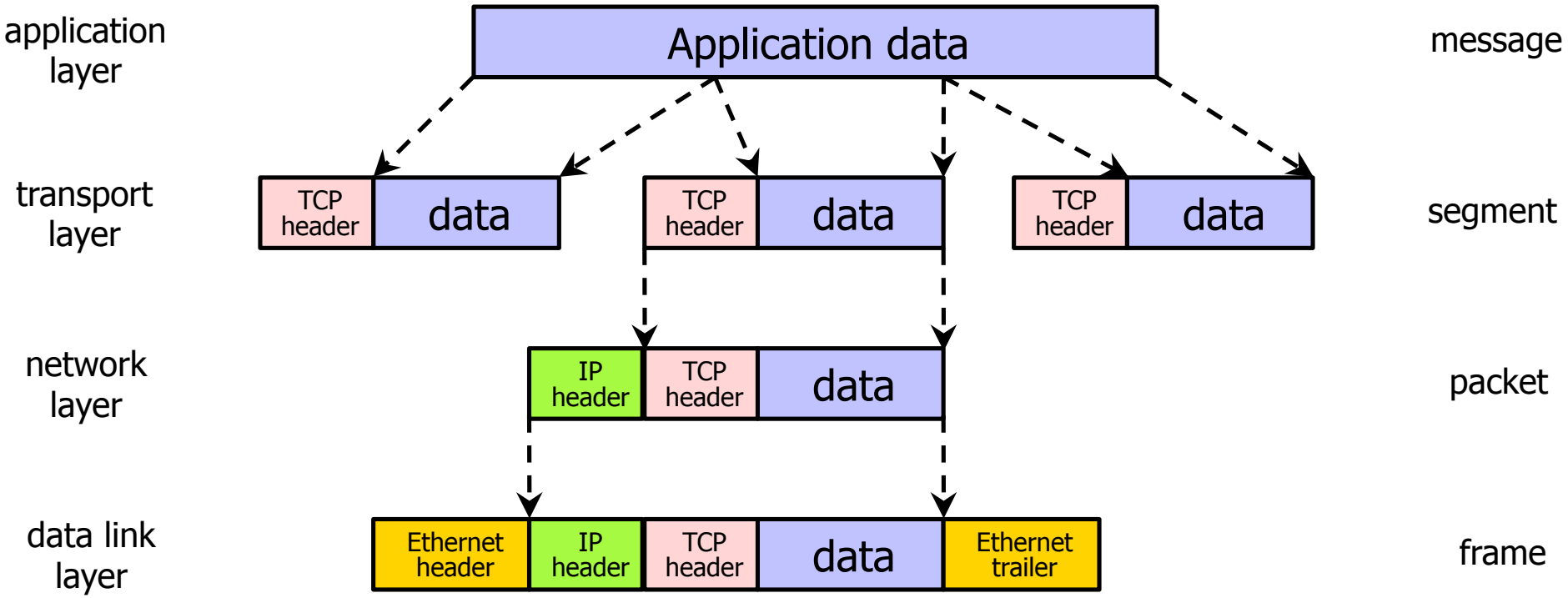
Spy on users

Identify anonymous users

OSI Protocol Stack

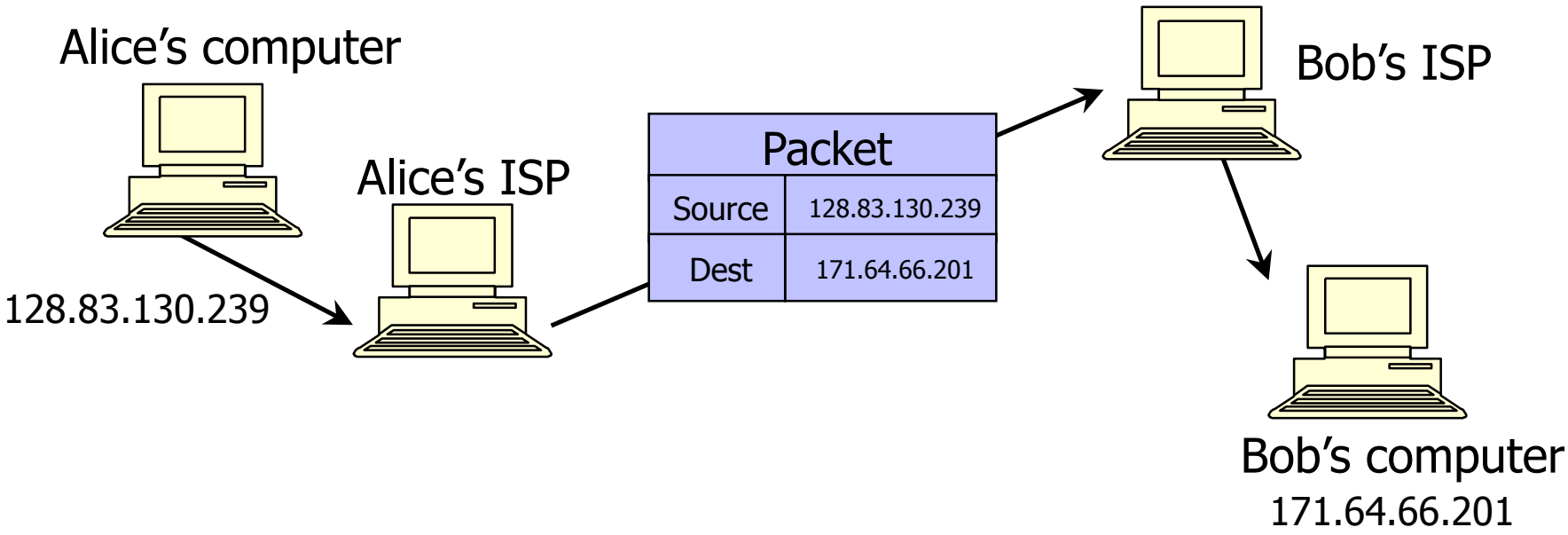


Data Formats



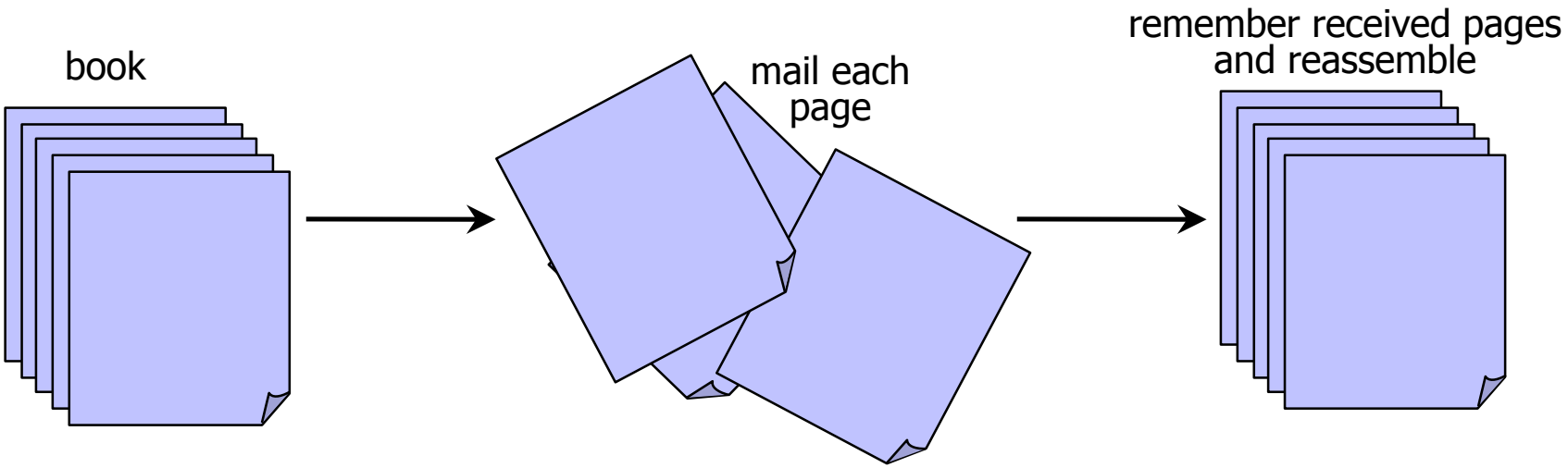
IP (Internet Protocol)

- Connectionless
  - Unreliable, "best-effort" protocol
- Uses numeric addresses for routing
  - Typically several hops in the route



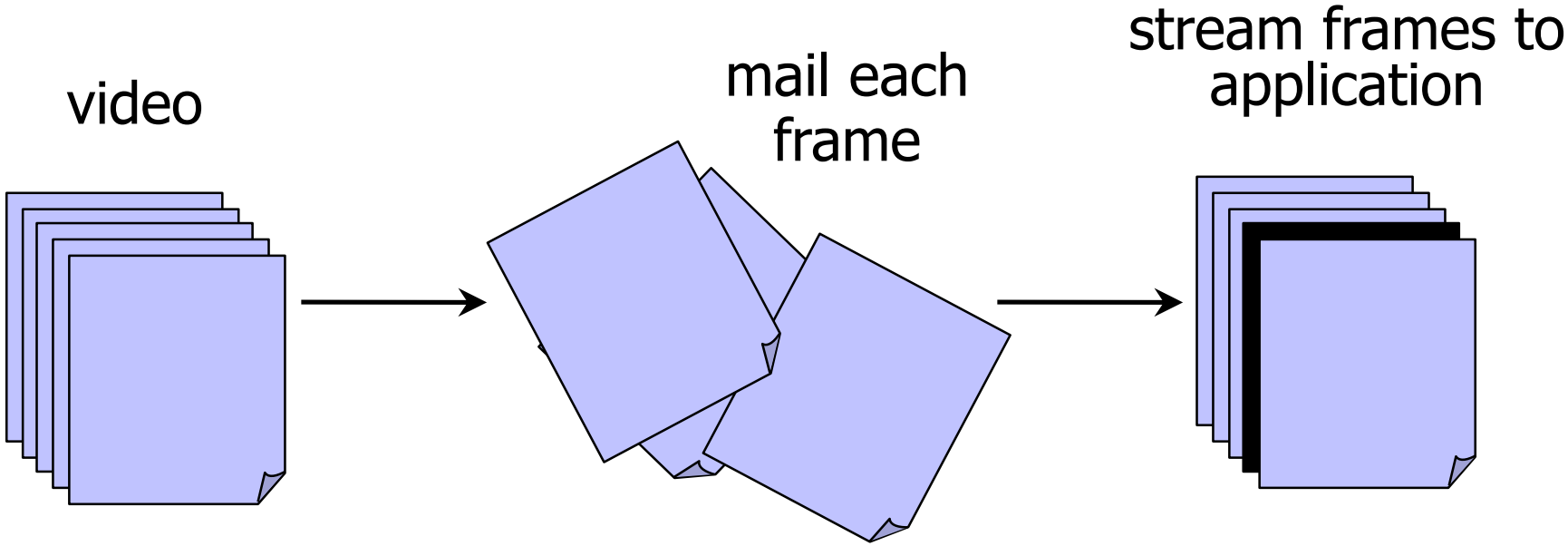
TCP (Transmission Control Protocol)

- Sender: break data into packets
  - Sequence number is attached to every packet
- Receiver: reassemble packets in correct order
  - Acknowledge receipt; lost packets are re-sent
- Connection state maintained on both sides



UDP (User Datagram Protocol)

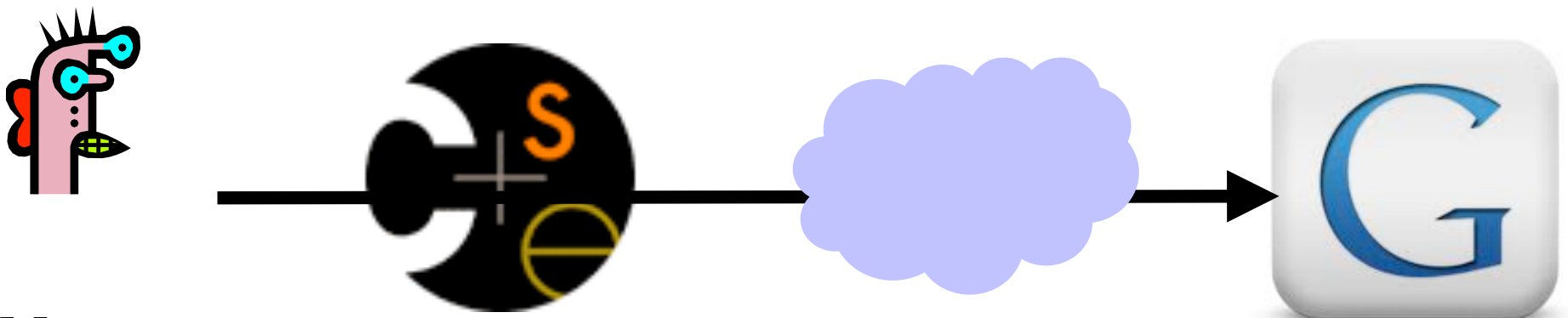
- Sender: break data into packets
  - Sequence number - maybe? If Application wants them
- Receiver: receive packets
  - No acknowledgement
  - Dropped packets are skipped - no retransmission



ICMP (Control Message Protocol)

- Provides feedback about network operation
  - "Out-of-band" messages carried in IP packets
  - Error reporting, congestion control, reachability, etc.
- Example messages:
  - Destination unreachable
  - Time exceeded
  - Parameter problem
  - Redirect to better gateway
  - Reachability test (echo / echo reply)
  - Message transit delay (timestamp request / reply)

(Some) Malicious Goals



User

Network Admin

Intermediate ISPs

Server

Launch undetectable attacks

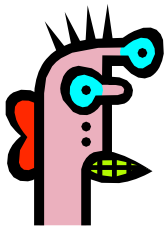
Probe for vulnerabilities

Spy on/tamper with traffic

Impersonate servers/users

Identify anonymous users

Detecting attacks



User

Launch undetectable attacks

- **Problem:** IP packets contain source IP address
- **Solution:** Spoof IP address

Inferring DDOS (Moore, Voelker, Savage '01)