Vietnam National University Ho Chi Minh City, University of Science
Department of Information Technology

*Topic 10:*

# Secured Socket Layer

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KHOA CÔNG NGHỆ THÔNG TIN
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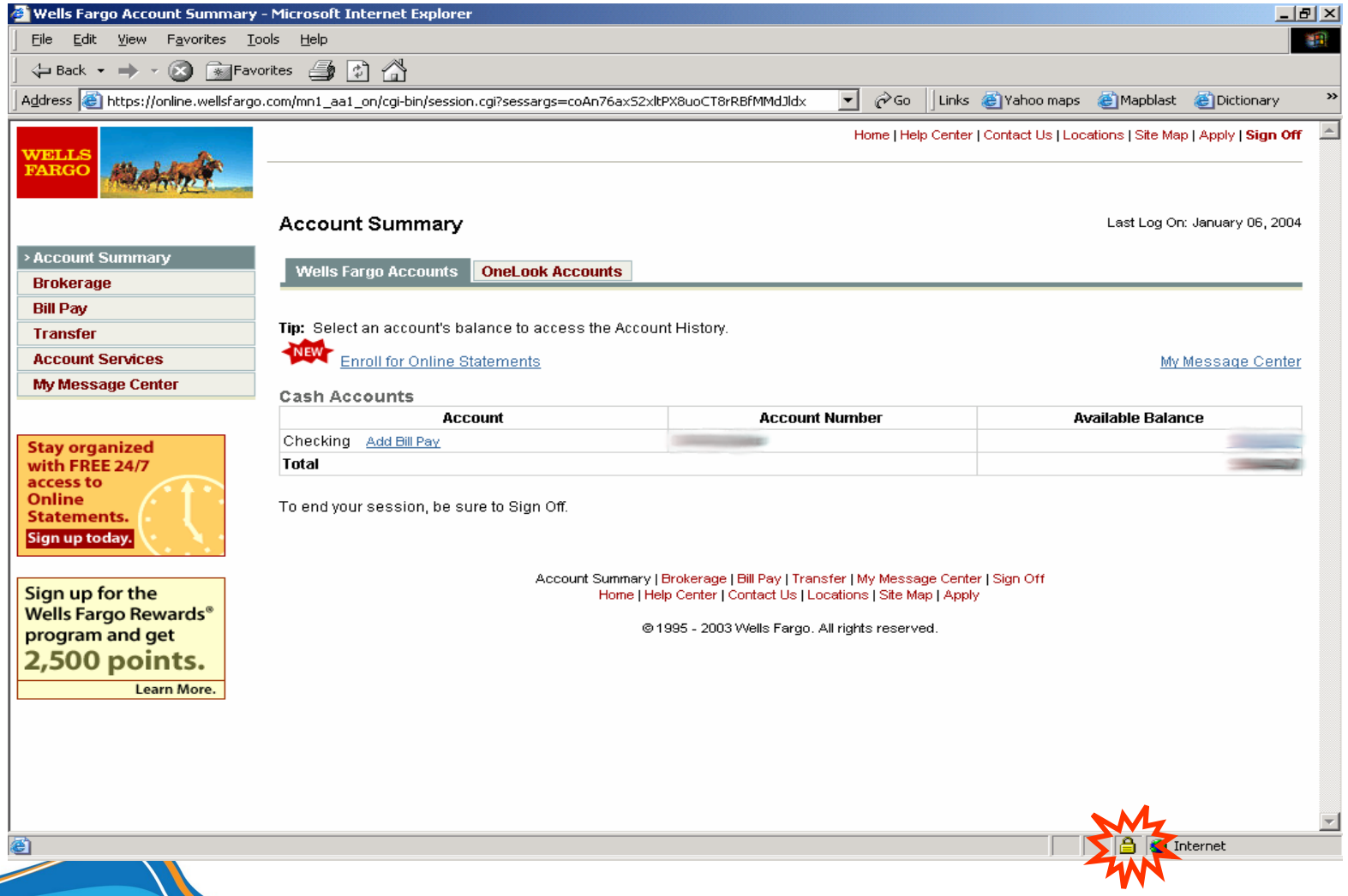
# SSL / TLS in daily life?



# The evolution of the protocol

- SSL 1.0
  - Internal research in Netscape (~early 1994?)
  - “Lost in the mists of time”
  - Main author: Taher Elgamal
- SSL 2.0
  - Netscape published on 11/1994
  - There are still a few problems
  - Expired on 2011 (RFC 6176)
- SSL 3.0
  - Published in RFC 6101
  - Netscape and Paul Kocher designed (11/1996)
  - Expired on 6/2015 (RFC 7568)

# The evolution of the protocol

- TLS 1.0 và TLS 1.1
  - Internet standards based on SSL 3.0 (01/1999)
  - Incompatible works with SSL 3.0
  - Expired on ~ 3/2020
  - TLS 1.1 updated from TLS 1.0
  - TLS 1.0 published in RFC 2246 and TLS 1.1 in RFC 4346
- TLS 1.2
  - Updated from TLS 1.1
  - Currently in use
  - Published in RFC 5246
- TLS 1.3
  - Updated from TLS 1.2
  - Used by some libraries, browsers and software
  - Published in RFC 8446

*https://datatracker.ietf.org/doc/html/rfc5246*

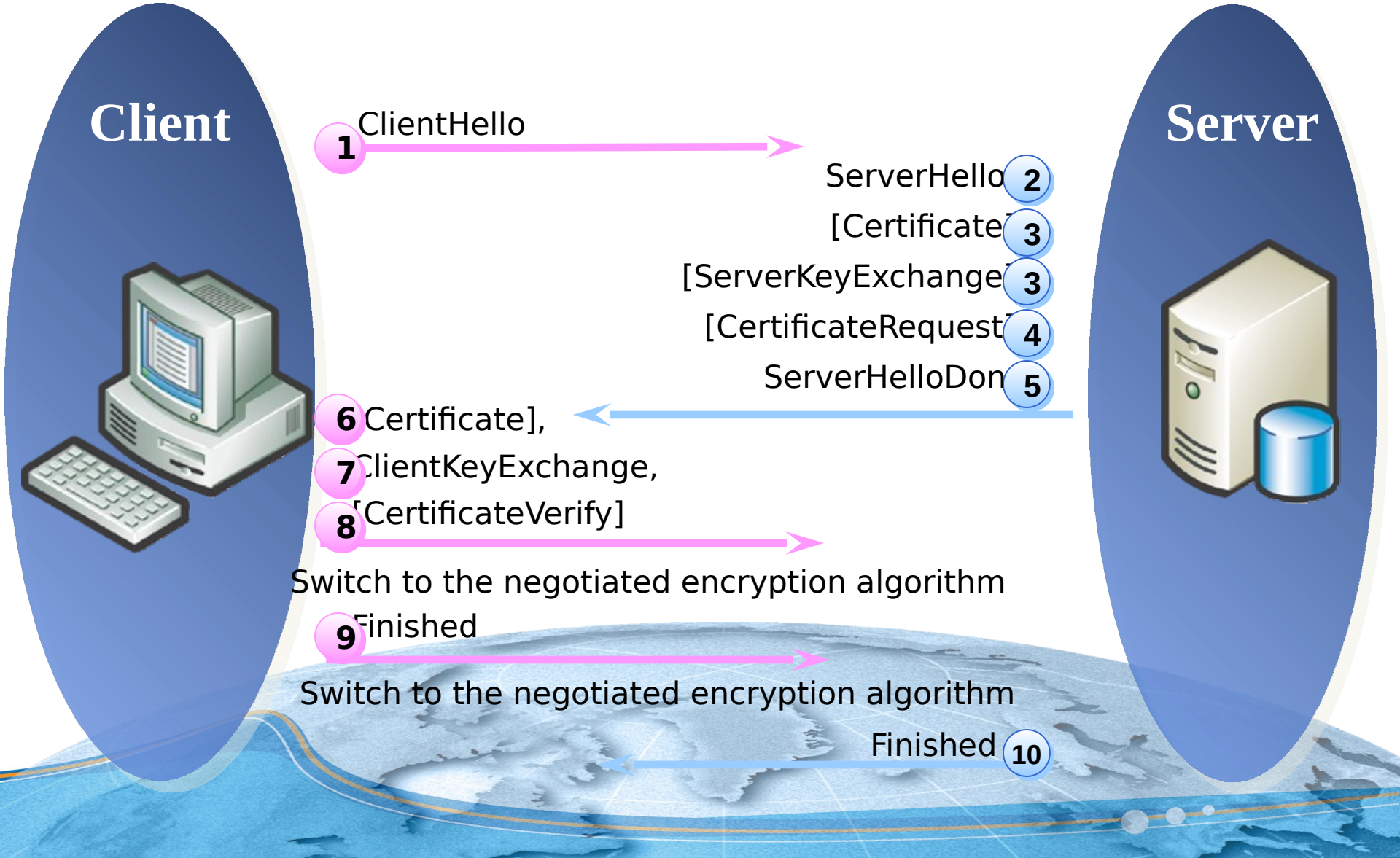
# Some limitations in SSL 2.0

- Key length is too short
  - In weakened modes before being released to the public, SSL 2.0 has narrowed the key length for authentication to 40 bits.
- Generate weak MAC
- Vulnerable to integrity attack
  - SSL 2.0 adds bytes (padding) to the MAC in block cipher modes, but has no control over padding length validation. This makes it possible for an attacker to delete some bytes at the end of the message.
- Ciphersuite rollback attack
  - An attacker can modify the “ClientHello” message to “trick” the server into choosing an old version or a weak algorithm

# Basics of TLS (TLS Handshake Protocol)

- TLS consists of two protocols:
  - **Handshake protocol**: use asymmetric encryption to establish a shared secret key between client and server
    - Include Client and Server
    - Negotiate protocol version and the set of cryptographic algorithms to be used
      - Compatibility & interoperability between different implementations of the general protocol
    - Authenticate client and server (optional)
      - Use an e-certificate to know the partner's public key and confirm each other's identity
    - Use public key to establish public-secret
  - **Record protocol:** Use the secret key established in the handshake protocol to protect communication between client and server

# Structure of Handshake protocol (in general)



# ClientHello

Client

Server

1 ClientHello

Client reports (data NOT encrypted):

- Version of in-use protocol
- Supported encryption algorithms

# ClientHello

- 4 bytes timestamp, 28 bytes random value
- session_id:
  - ≠ 0 for new connection of existing session
  - = 0 for new connection of new session
- client_version: maximum version value
- cipher_suites: Ordered list of supported client algorithms
- compression_methods: an ordered list of compression algorithms that the client supports

```
struct {
   TimeStamp   timestamp;
   ProtocolVersion     client_version;
   Random         random;
   SessionID      session_id;
   CipherSuite          cipher_suites;
   CompressionMethod
compression_methods;
} ClientHello
```

**Highest version of the protocol supported by the client**

**Session id (if the client wants to resume an old session)**

**Client-supported cryptographic algorithms (e.g., RSA or Diffie-Hellman)**

# ServerHello

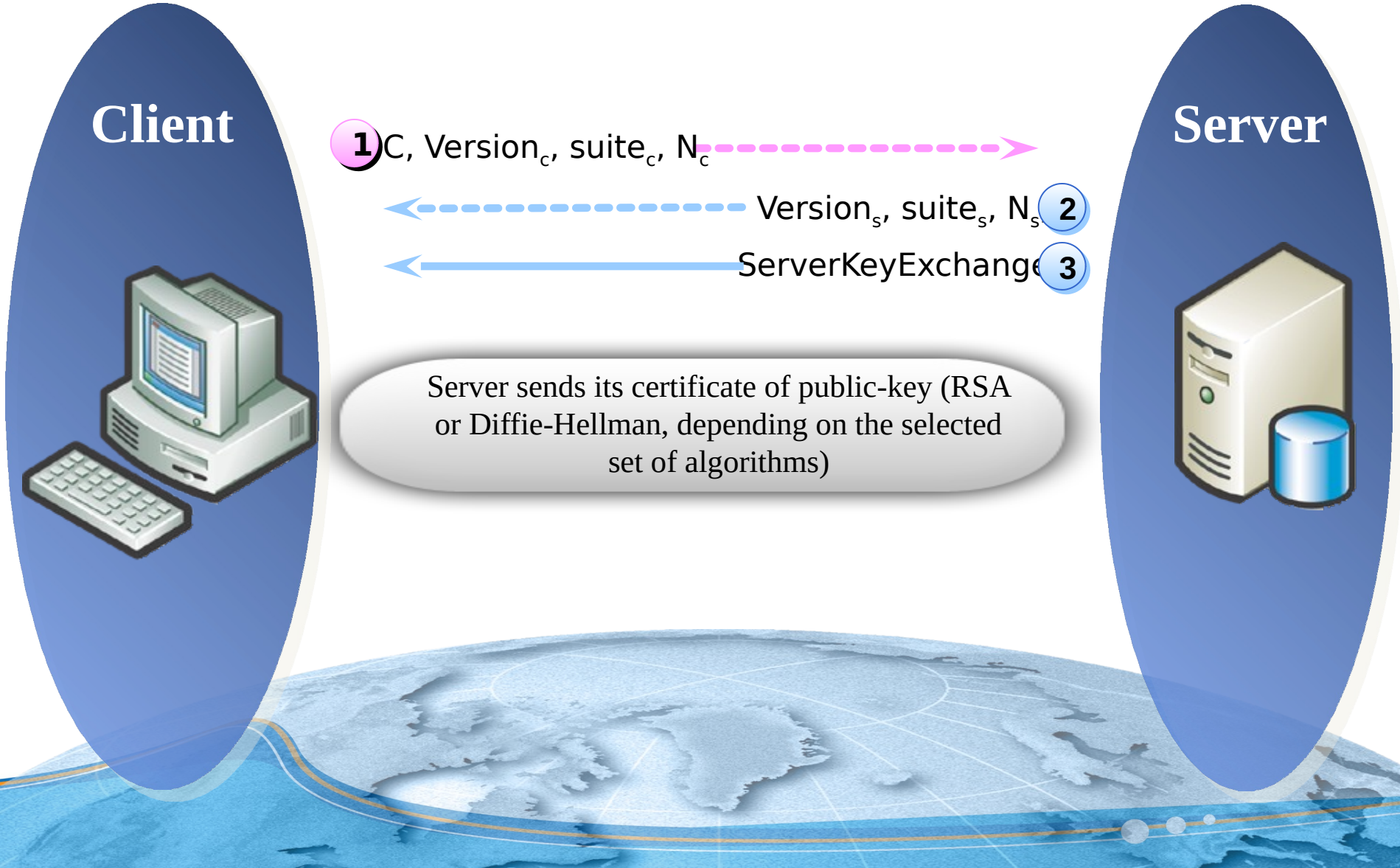
# ServerHello

- The structure consists of
  - 32 bytes random value
  - session_id: new value or old value reused
  - version: min{$version_{client\ supports}$, $version_{maximum\ server\ supports}$}
  - cipher_suite list: list of selected algorithms (select only one algorithm in each category)
  - compression list: Select only from client-supported compression algorithms
  - Key exchange method
    - RSA: need to certify the recipient's public key
    - Fixed DH: Both parties must have a public-key certificate
    - Ephemeral DH: Both sides need the key to sign and certify the public-key
    - Anonymous DH: don’t validate DH key, man-in-the-middle attack possible
    - Fortezza: rarely used

# ServerHello

- CipherAlgorithm
  - RC4, RC2, DES, 3DES, DES40, IDEA, Fortezza
- MACAlgorithm
  - MD5 or SHA-1
- CipherType
  - stream or block
- IsExportable: true or false
- HashSize
  - 0, 16 or 20 bytes
- Key Material: used to generate a write-key
- IV Size: size of IV in CBC

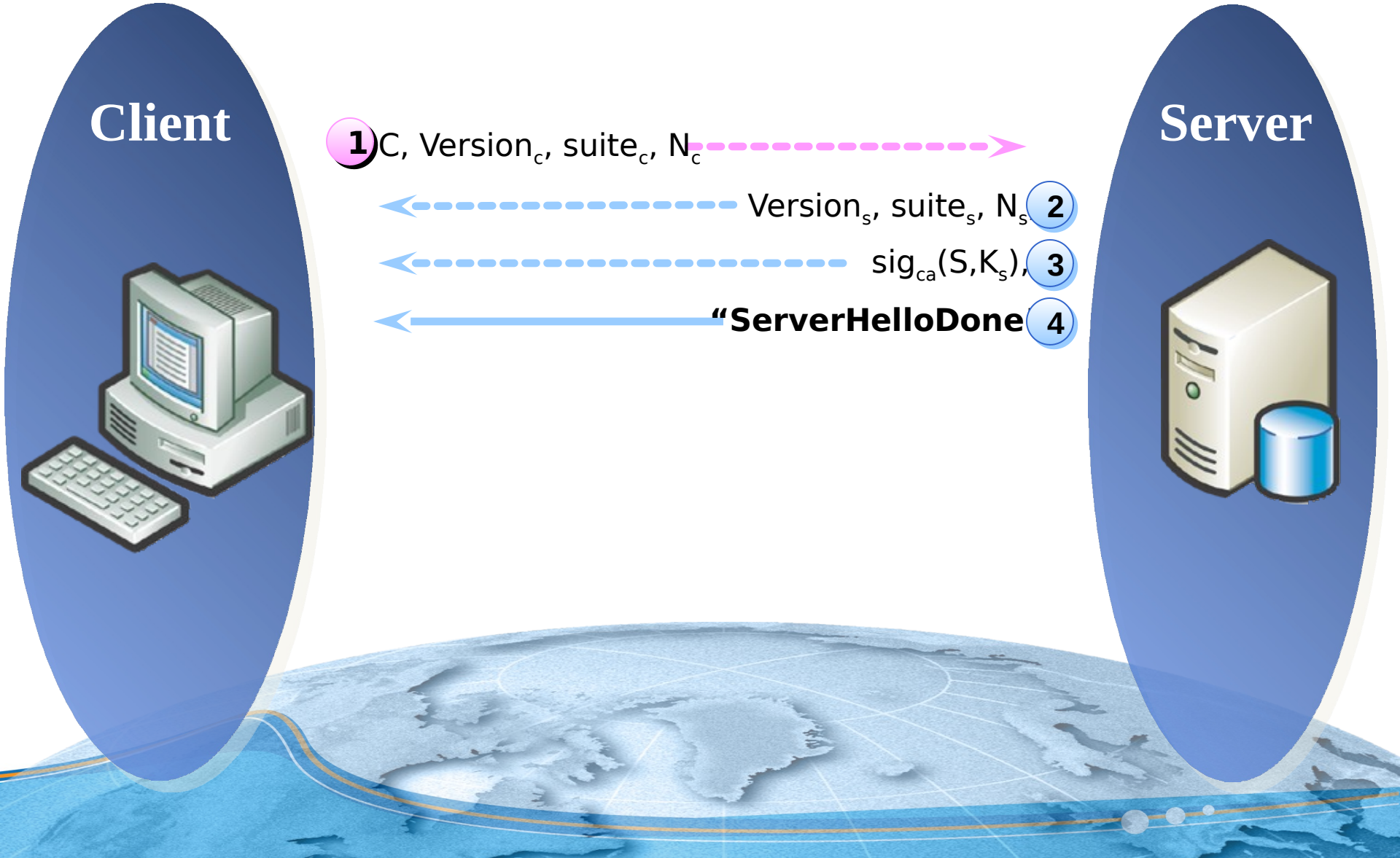
# ServerKeyExchange



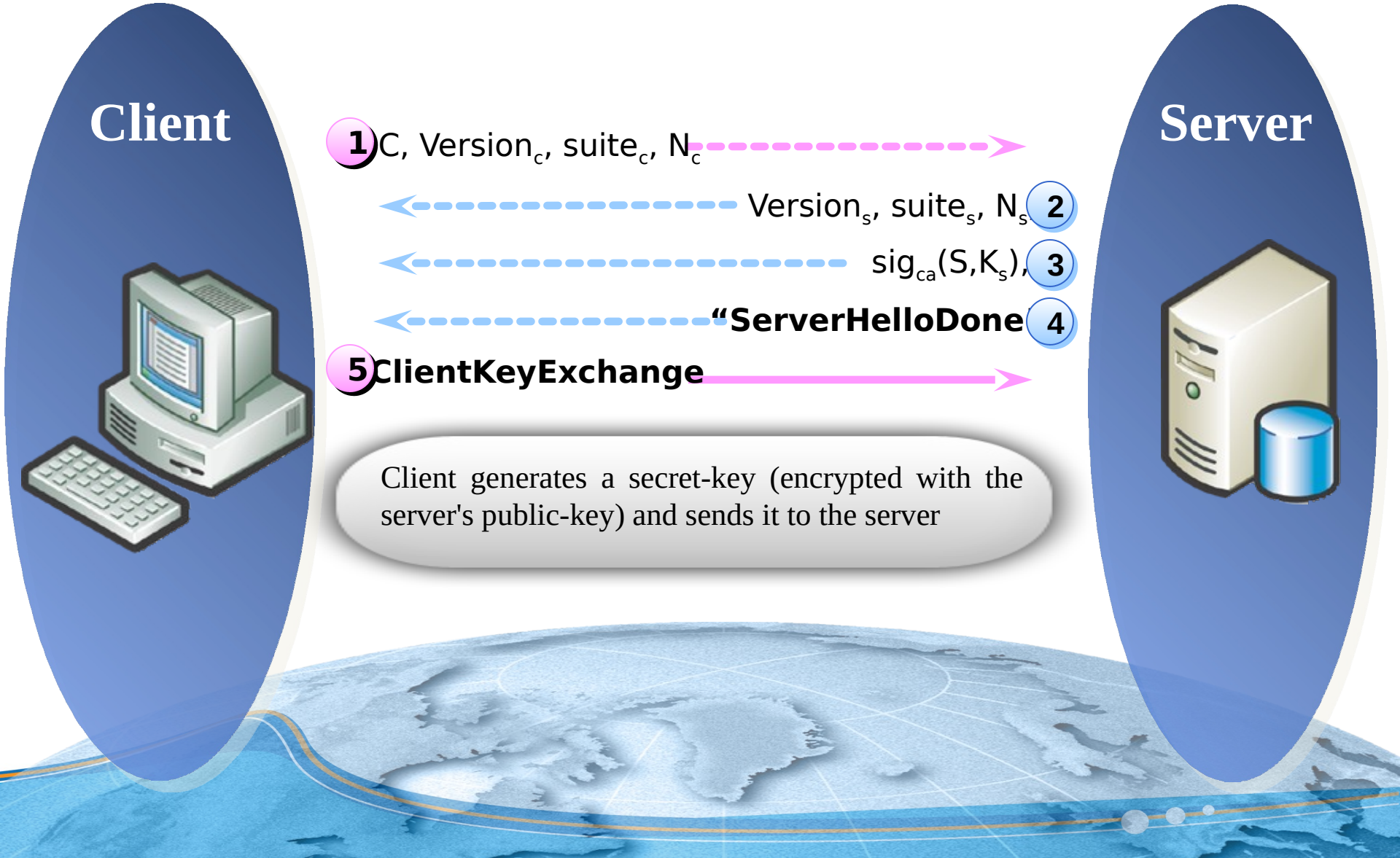
# ServerKeyExchange

- No need for RSA and Fixed DH
- Needed with Anonymous DH, Ephemeral DH
- Use with RSA if the server only has a key for signing. The server then sends a temporary public key (RSA) to the client
- Message ServerKeyExchange:
  - Signed by server
  - Signature on hash value of:
    - ClientHello.random, ServerHello.random
    - Parameter of Server Key Exchange

# ClientKeyExchange



# ClientKeyExchange



# ClientKeyExchange

- Structure

```
struct {
   select (KeyExchangeAlgorithm) {
      case rsa: EncryptedPreMasterSecret;
      case diffie_hellman:
ClientDiffieHellmanP
   } exchange_keys
} ClientKeyExchange

struct {
   ProtocolVersion client_
   opaque random[46];
} PreMasterSecret
```

**RSA or Diffie-Hellman key exchange algorithm**

**Client-side protocol version**

# "Core" SSL



1 C, $Version_c$, $suite_c$, $N_c$ →

← $Version_s$, $suite_s$, $N_s$ 2

← $sig_{ca}(S,K_s)$, 3

← "ServerHelloDone 4

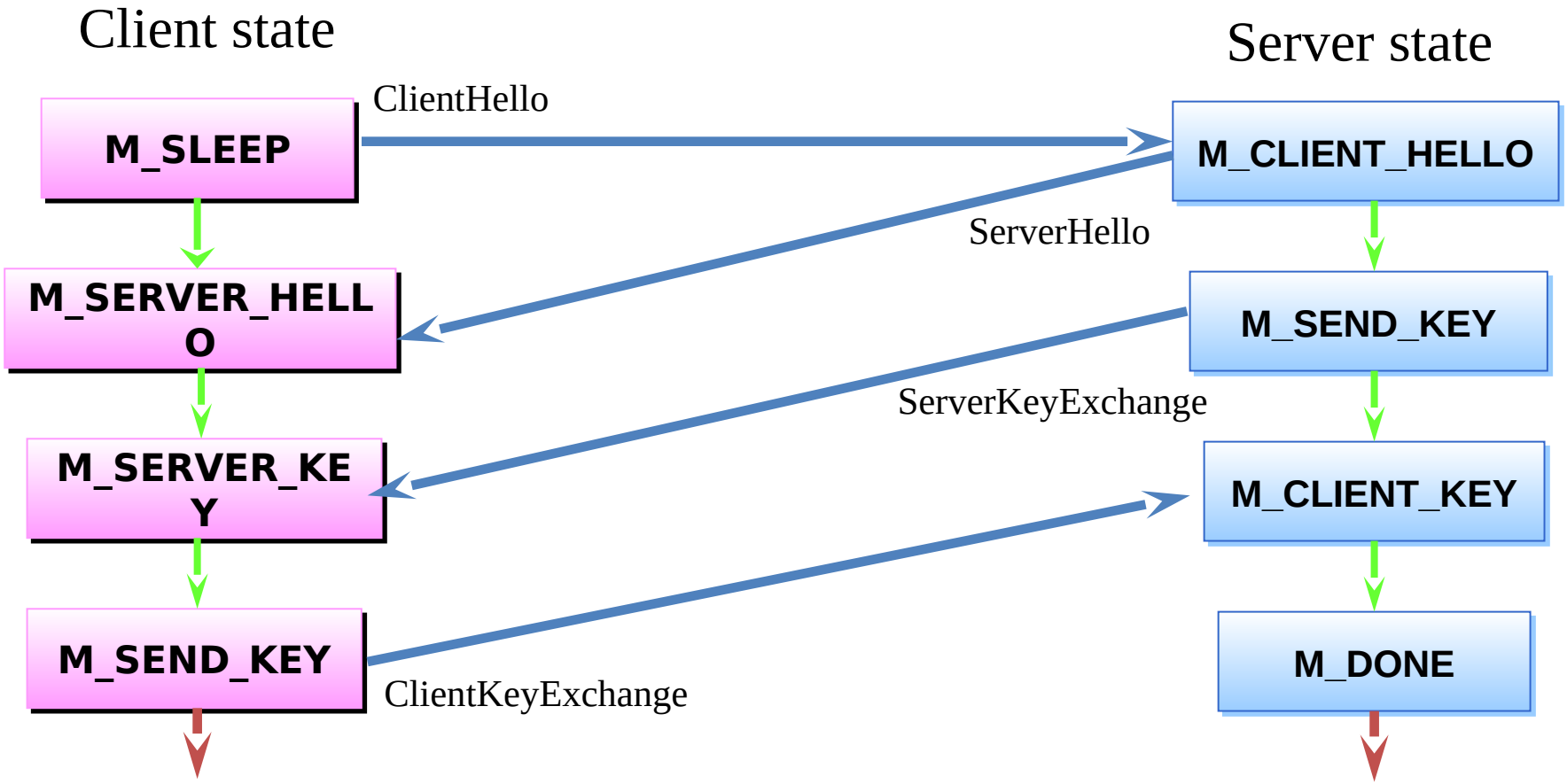
5 $\{Secret_c\}_{Ks}$ →

If the protocol is correct, from now on, C and S share a common secret key

**Switch to using key deduced from $secret_c$**

**Switch to using key deduced from $secret_c$**

# States of Client and Server



# Main part of SSL 3.0



1 C, **Version$_c$ = 3.0,** suite$_c$, N$_c$ →

← Version$_s$ = 3.0, suite$_s$, N$_s$ 2

← sig$_{ca}$(S,K$_s$), 3

← "ServerHelloDone 4

5 {Secret$_c$}$_{Ks}$ →

If the protocol is correct, from now on,
C and S share the common secret key

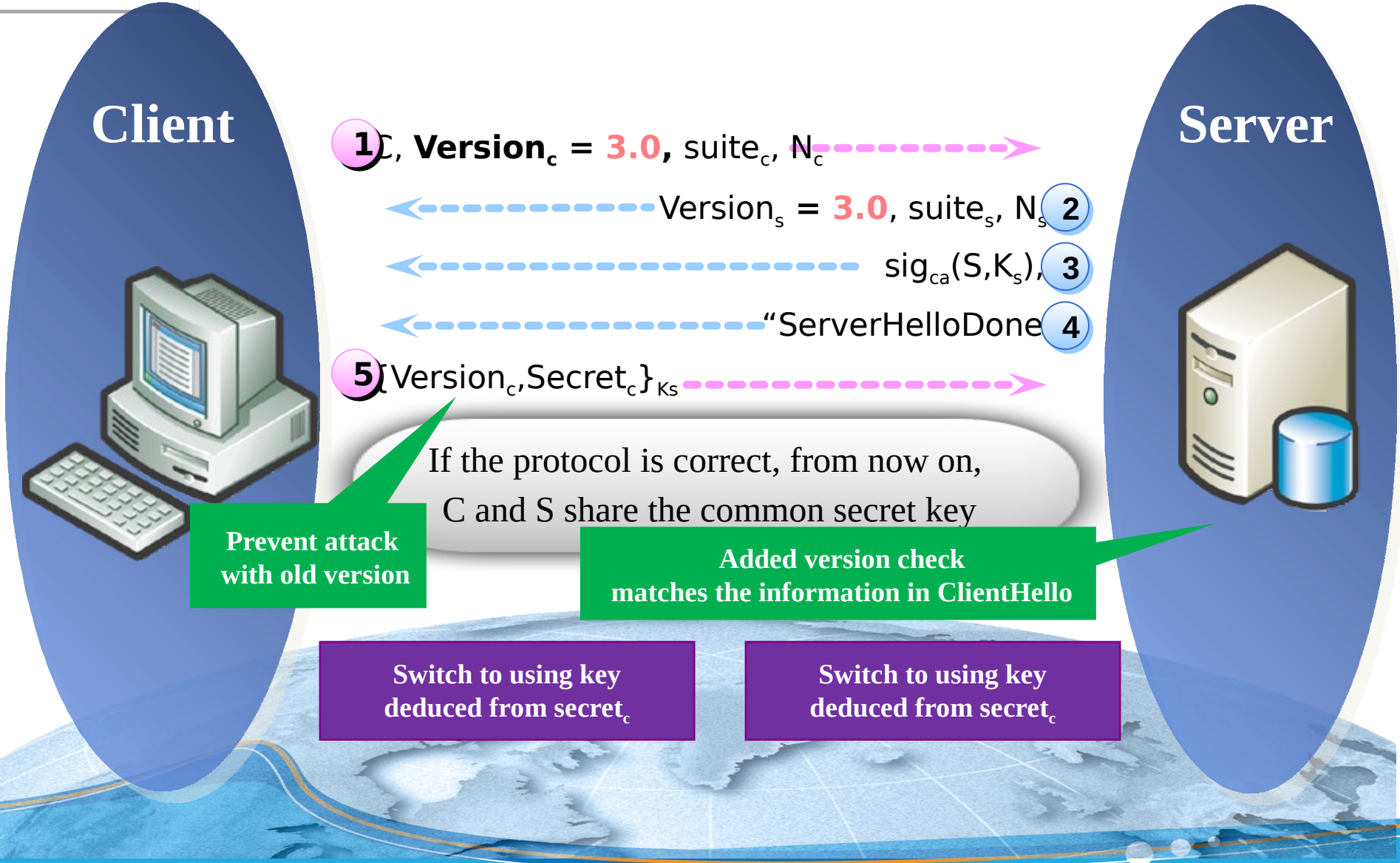
**Switch to using key deduced from secret$_c$**

**Switch to using key deduced from secret$_c$**

# Mis-choose old version!


**The server was "tricked" and decided to establish communication between S and C using the old version**

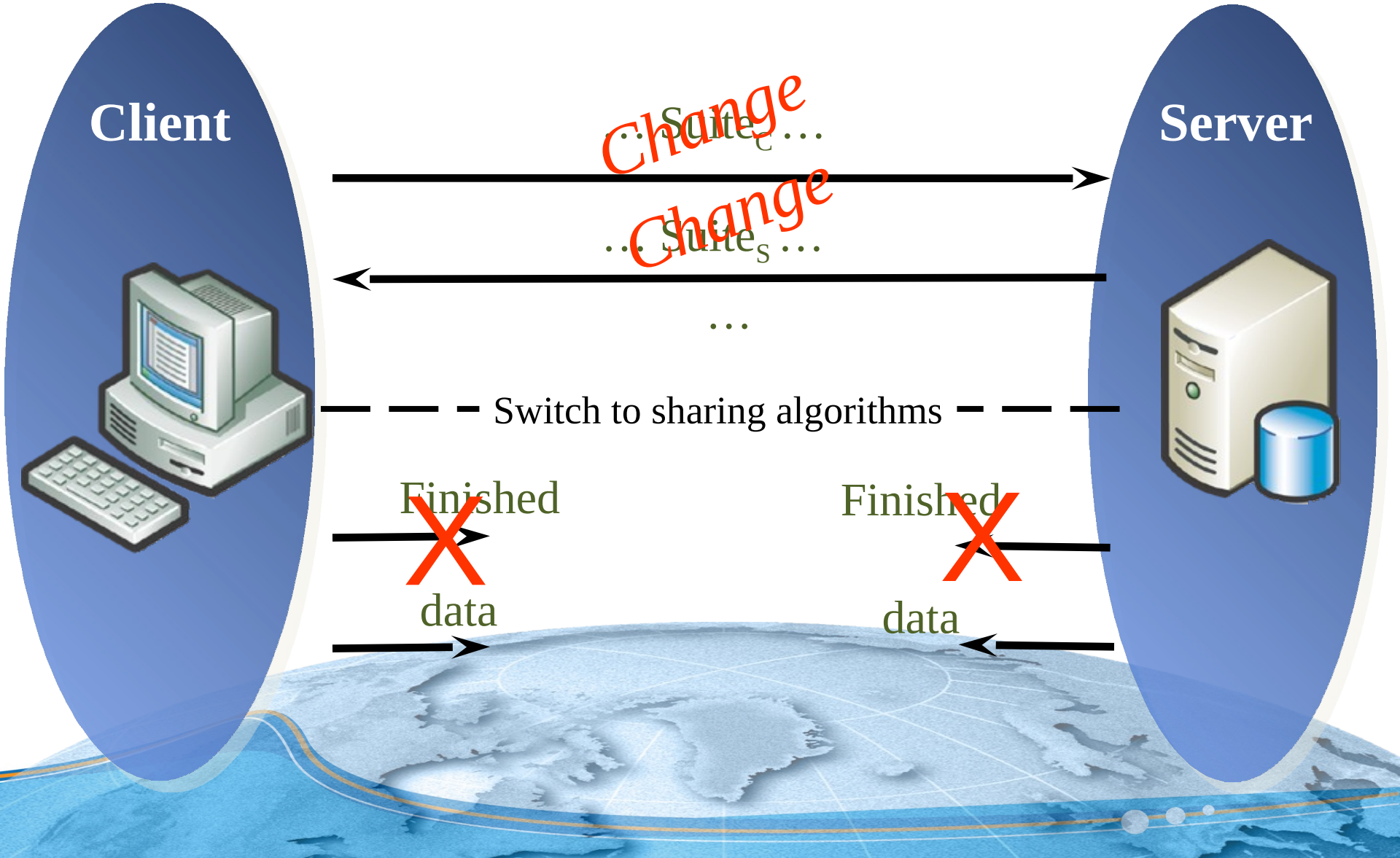
# Adjust SSL


Client
Server
1 C, Version$_c$ = 3.0, suite$_c$, N$_c$
Version$_s$ = 3.0, suite$_s$, N$_s$ 2
sig$_{ca}$(S,K$_s$), 3
"ServerHelloDone 4
5 {Version$_c$,Secret$_c$}$_{Ks}$
If the protocol is correct, from now on,
C and S share the common secret key
Prevent attack with old version
Added version check matches the information in ClientHello
Switch to using key deduced from secret$_c$
Switch to using key deduced from secret$_c$

# Summary

- A = basic protocol
- C = A + certificate of public key
  - Authentication for client and server
- E = C + confirmation message (Finished)
  - Prevent attacks from “tricking” the server to choose the old version or weak algorithms
- F = E + nonse
  - Prevent replay attack

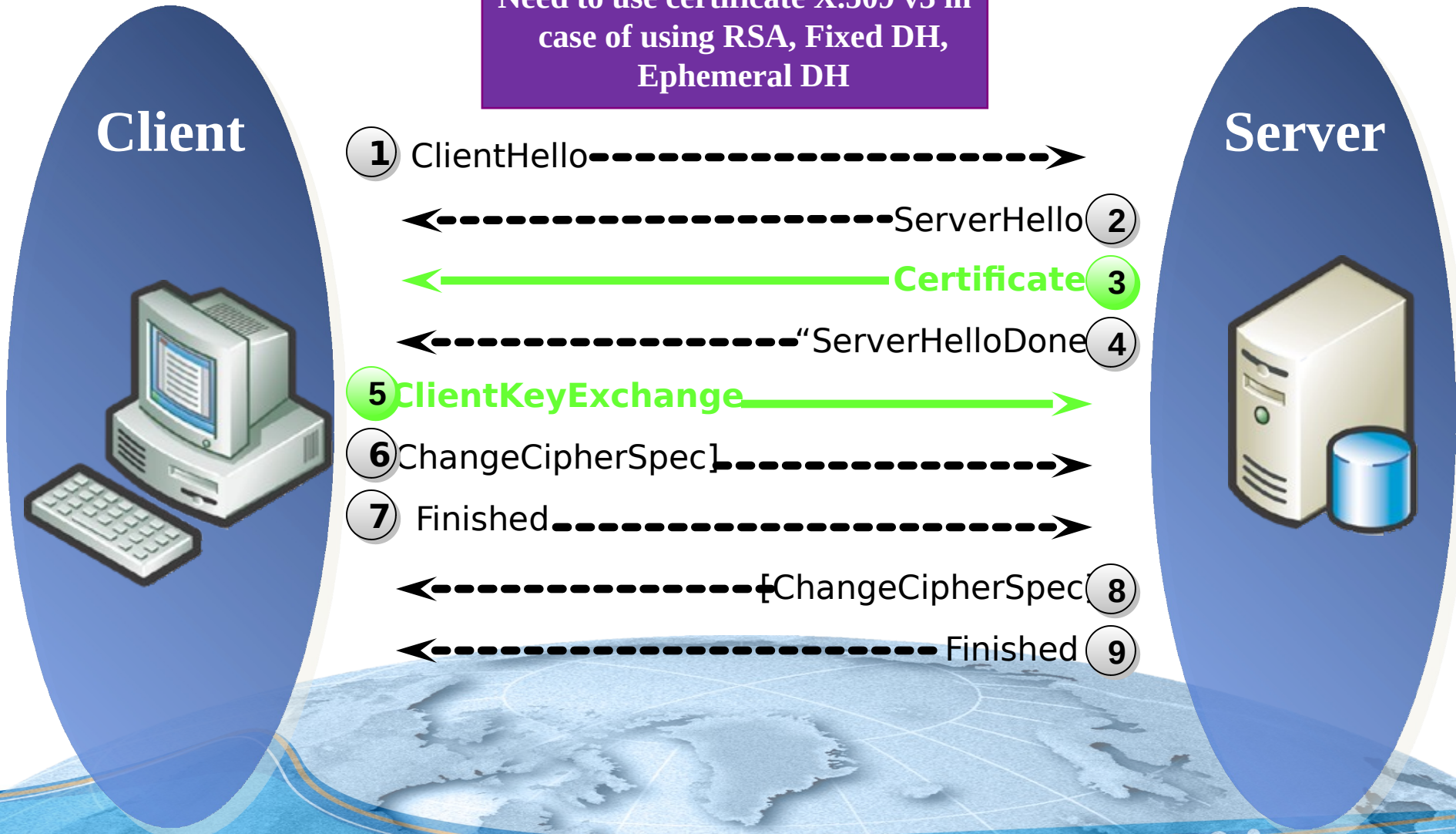
# Anomaly detection with Finished



# Example: Version Rollback Attack

# Server Authentication

**Need to use certificate X.509 v3 in case of using RSA, Fixed DH, Ephemeral DH**



# Server & Client Authentication