Module 2.4
SSL Handshake Protocol

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SSL Session

- SSL session negotiated by handshake protocol
  - session ID
    - chosen by server
  - X.509 public-key certificate of peer
    - possibly null
  - compression algorithm
  - cipher spec
    - encryption algorithm
    - message digest algorithm
  - master secret
    - 48 byte shared secret
  - is resumable flag
    - can be used to initiate new connections
    - each session is created with one connection, but additional connections within the session can be further created

SSL Handshake Protocol

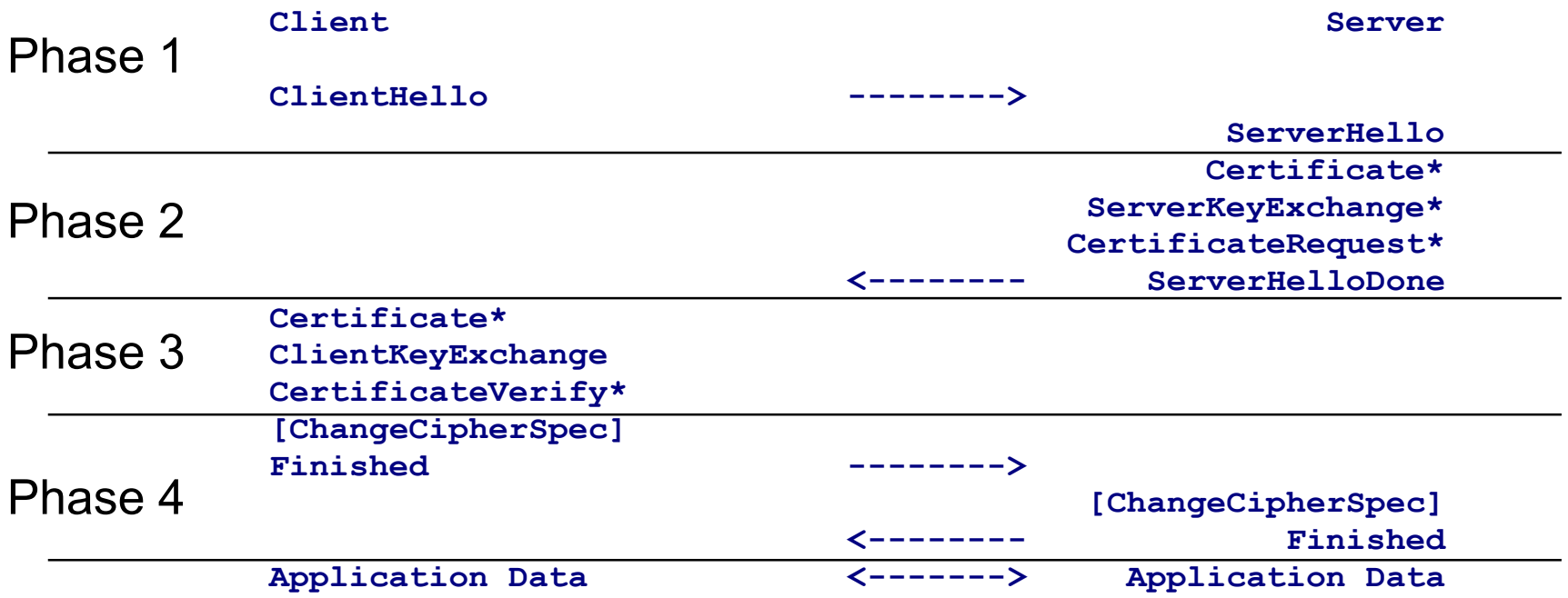


Fig. 1 - Message flow for a full handshake

* Indicates optional or situation-dependent messages that are not always sent.

Plaintext: Until and including ChangeCipherSpec message

Encrypted and MAC-ed: All subsequent messages

4-round message exchange

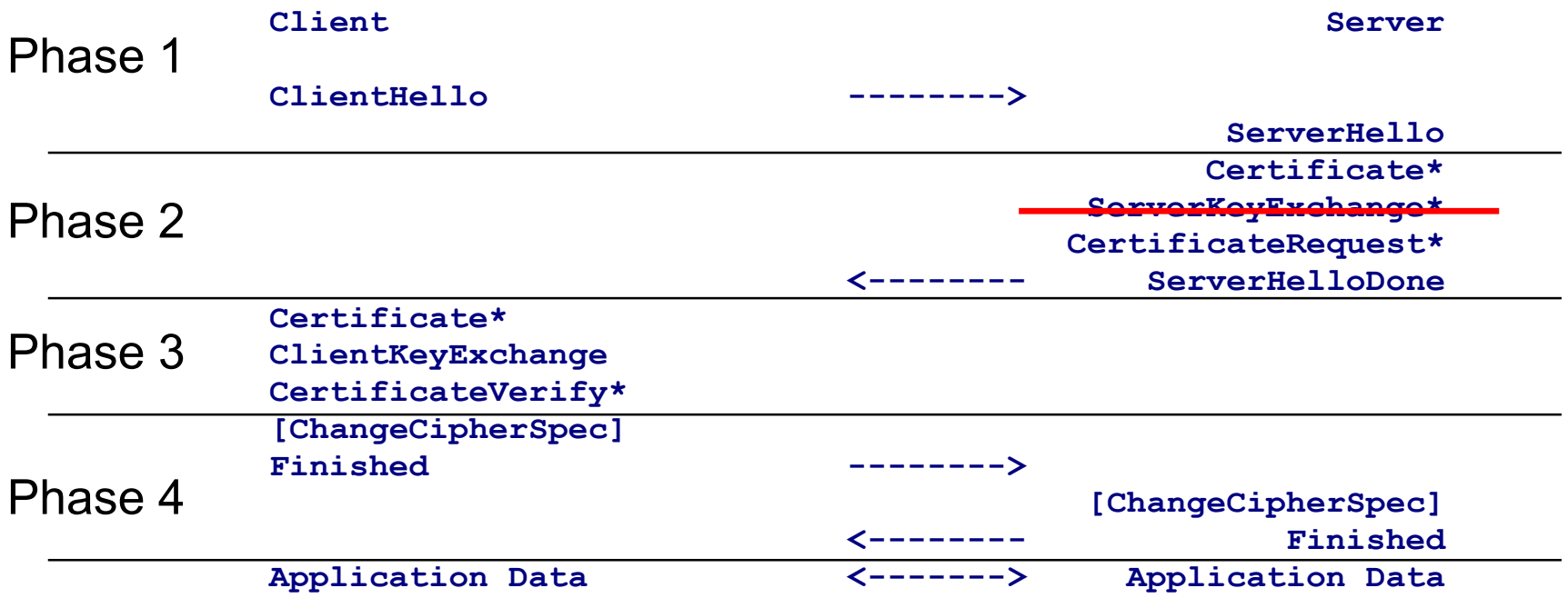
SSL Handshake Protocol

- these handshake messages must occur in order
- optional messages can be eliminated

- change_cipher_spec is a separate 1 message protocol
  - functionally just like a message in the handshake protocol

- post-handshake message to renegotiate
  - hello_request
  - can be sent anytime from server to client to request client to start handshake protocol to renegotiate session

SSL 2-Way Handshake with RSA



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SSL 2-Way Handshake with RSA

- Phase 1:
  - Establish security capabilities
- Phase 2:
  - Server authentication
- Phase 3:
  - Client authentication and key exchange
- Phase 4:
  - Finish

SSL RSA 2-way Handshake Phase 1

Phase 1: Establish security capabilities

- client hello message
  - 4 byte timestamp, 28 byte random value
  - session ID:
    - non-zero for new connection on existing session
    - zero for new connection on new session
  - client version: highest version
  - cipher_suite list: ordered list
    - key exchange method, encryption method, MAC method
  - compression list: ordered list
- server hello message
  - 32 byte random value
  - session ID:
    - new or reuse
  - version
    - lower of client suggested and highest supported
  - cipher_suite list: single choice
  - compression list: single choice

Phase 2: Server authentication

- certificate message
  - server's X.509v3 certificate along with chain of certificates
  - required for RSA
- certificate request message
  - request a certificate from client
  - specifies Certificate Type and Certificate Authorities
- server done message
  - ends phase 2, always required

SSL 2-way Handshake Phase 3

Phase 3: Client authentication and key exchange

- certificate message
  - client's X.509v3 certificate along with chain of certificates
- client key exchange message
  - client generates 48-byte pre-master secret, encrypts with server's RSA public key
- certificate verify message
  - signs hash of master secret (established by key exchange) and all handshake messages so far

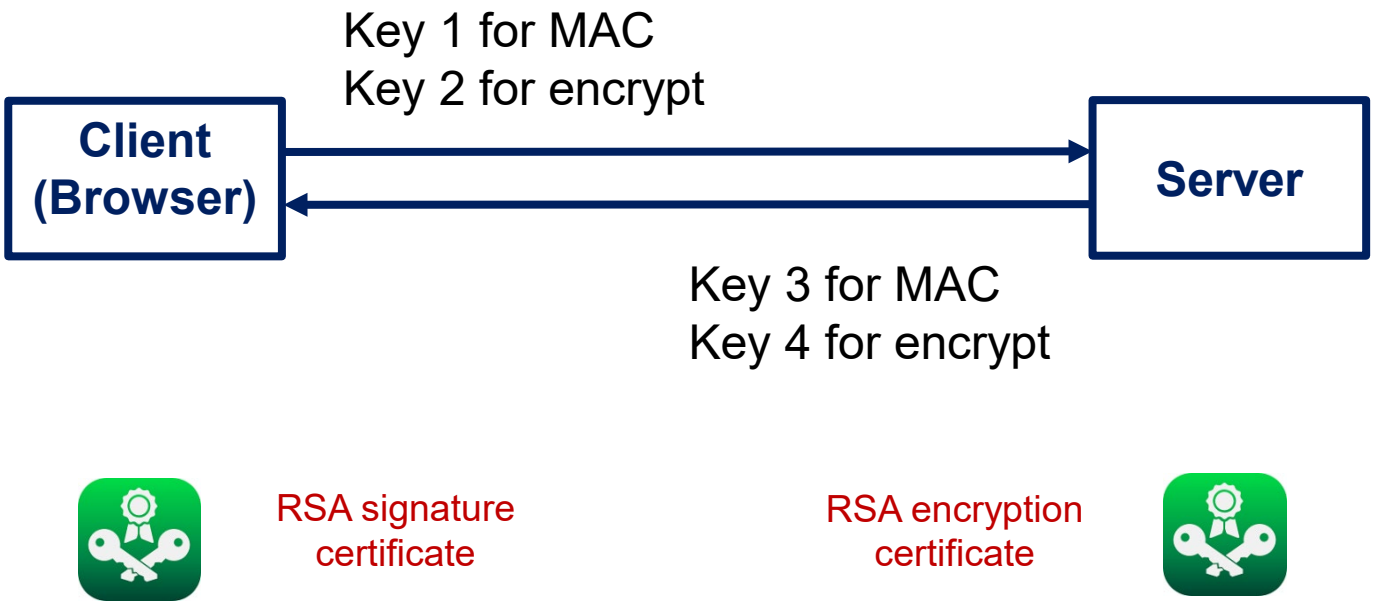
- client and server compute 48 byte master secret
  - using 48-byte pre-master secret, ClientHello.random, ServerHello.random
- client and server compute 4 symmetric keys from master secret

SSL 2-way RSA Handshake Phase 4

Phase 4: Finish and move to record protocol

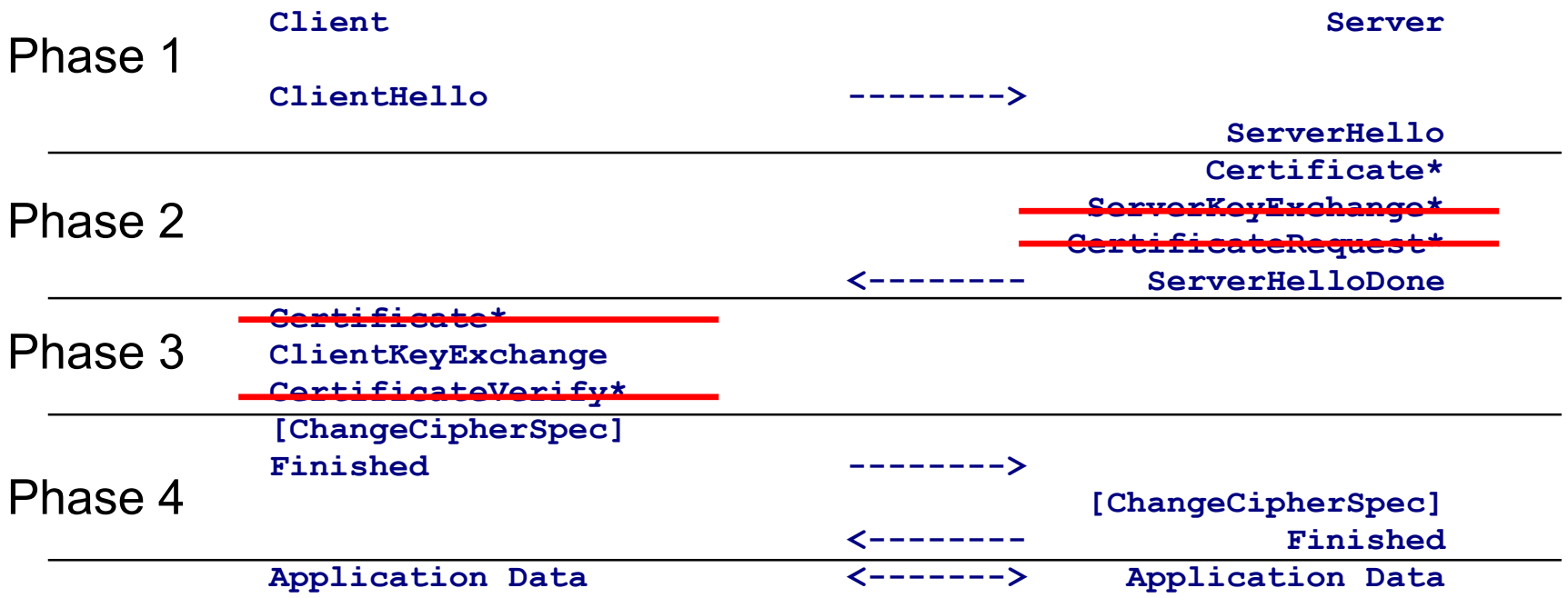
- change cipher spec message
  - not considered part of handshake protocol but in some sense is part of it
  - 1 byte message
- Finished message
  - sent under new algorithms and keys
  - content is MAC of all previous messages with master secret and constant “client finished” or “server finished”

SSL 2-way RSA Handshake Result



Mutually authenticated secure channel

SSL 1-Way Handshake with RSA



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No change relative to SSL RSA 2-way Handshake Phase 1

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SSL 1-way Handshake Phase 3

Phase 3: Client ~~authentication and~~ key exchange

- ~~certificate message~~
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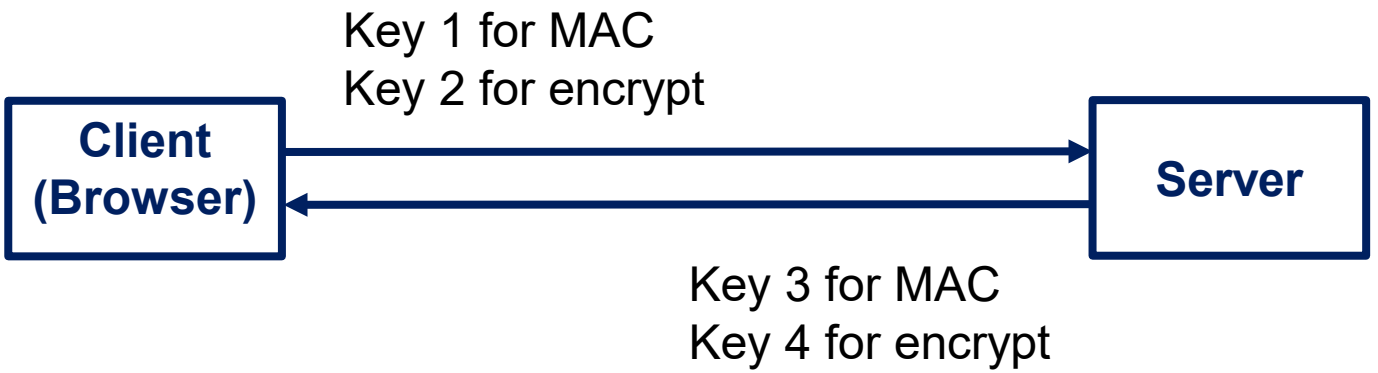

Server-to-client authenticated secure channel

Client-to-server authentication via user ID and password