Security Protocols

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Acknowledgments

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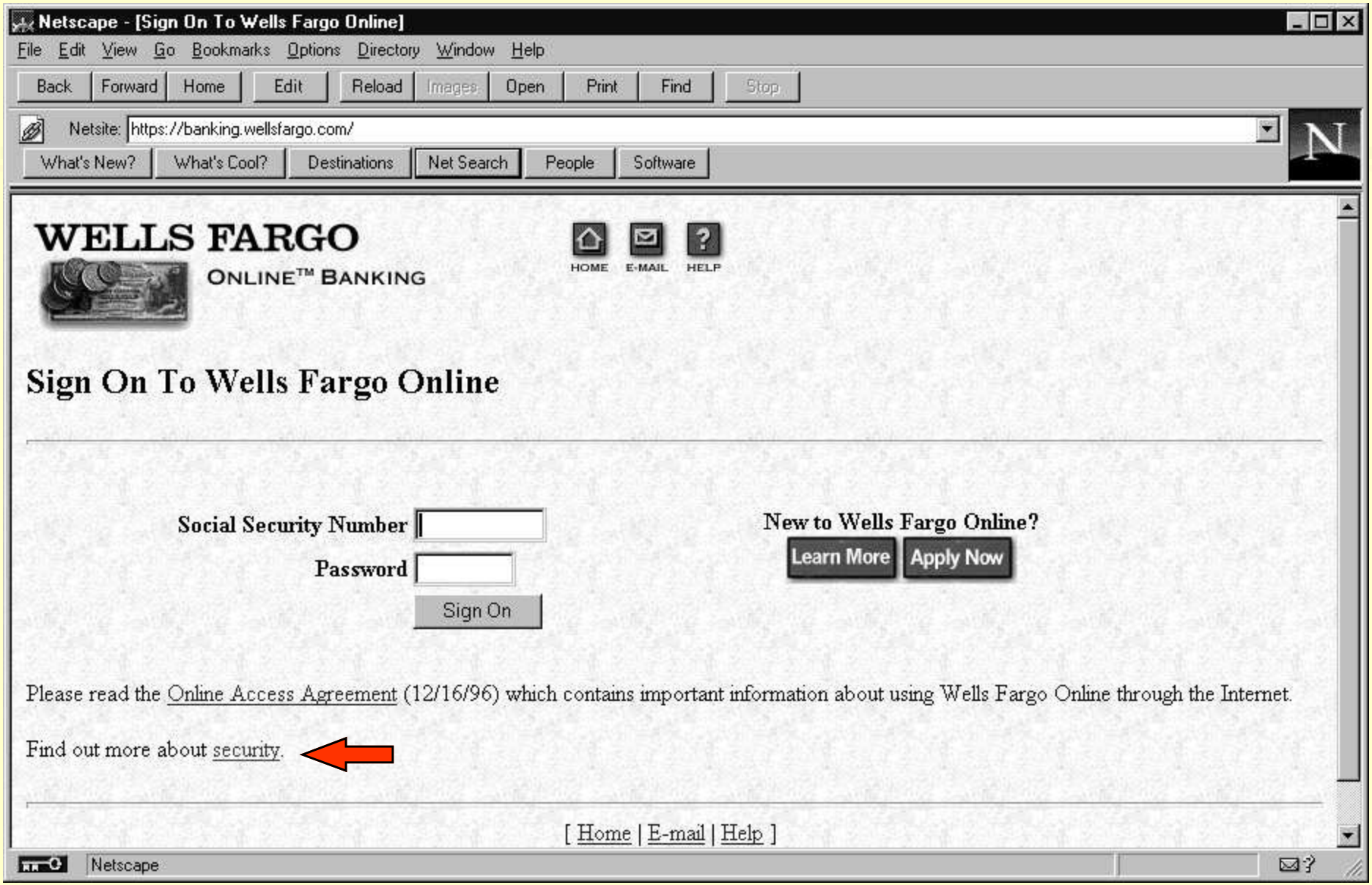
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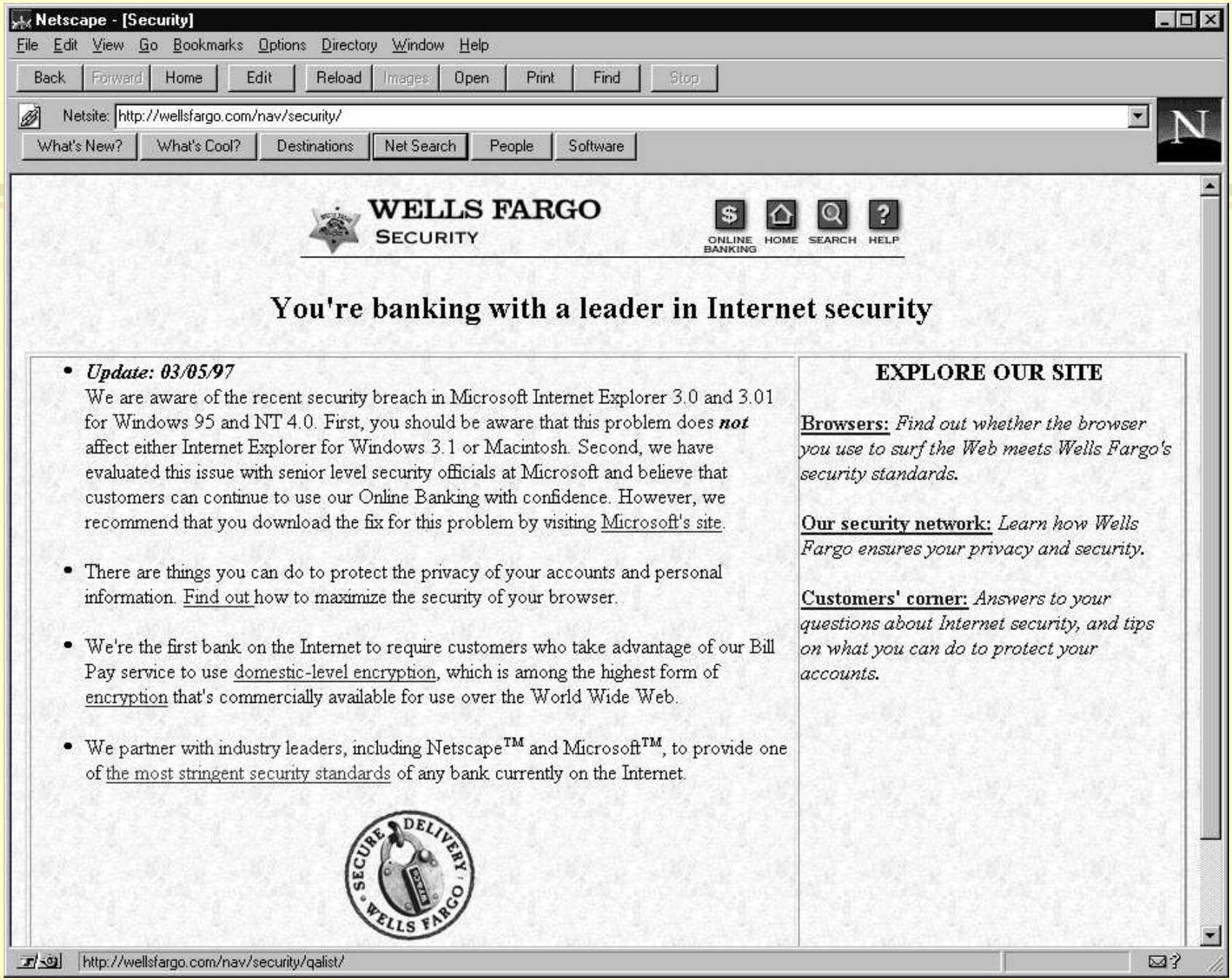
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There are things you can do to protect the privacy of your accounts and personal information. Find out how to maximize the security of your browser.
We're the first bank on the Internet to require customers who take advantage of our Bill Pay service to use domestic-level encryption, which is among the highest form of encryption that's commercially available for use over the World Wide Web.
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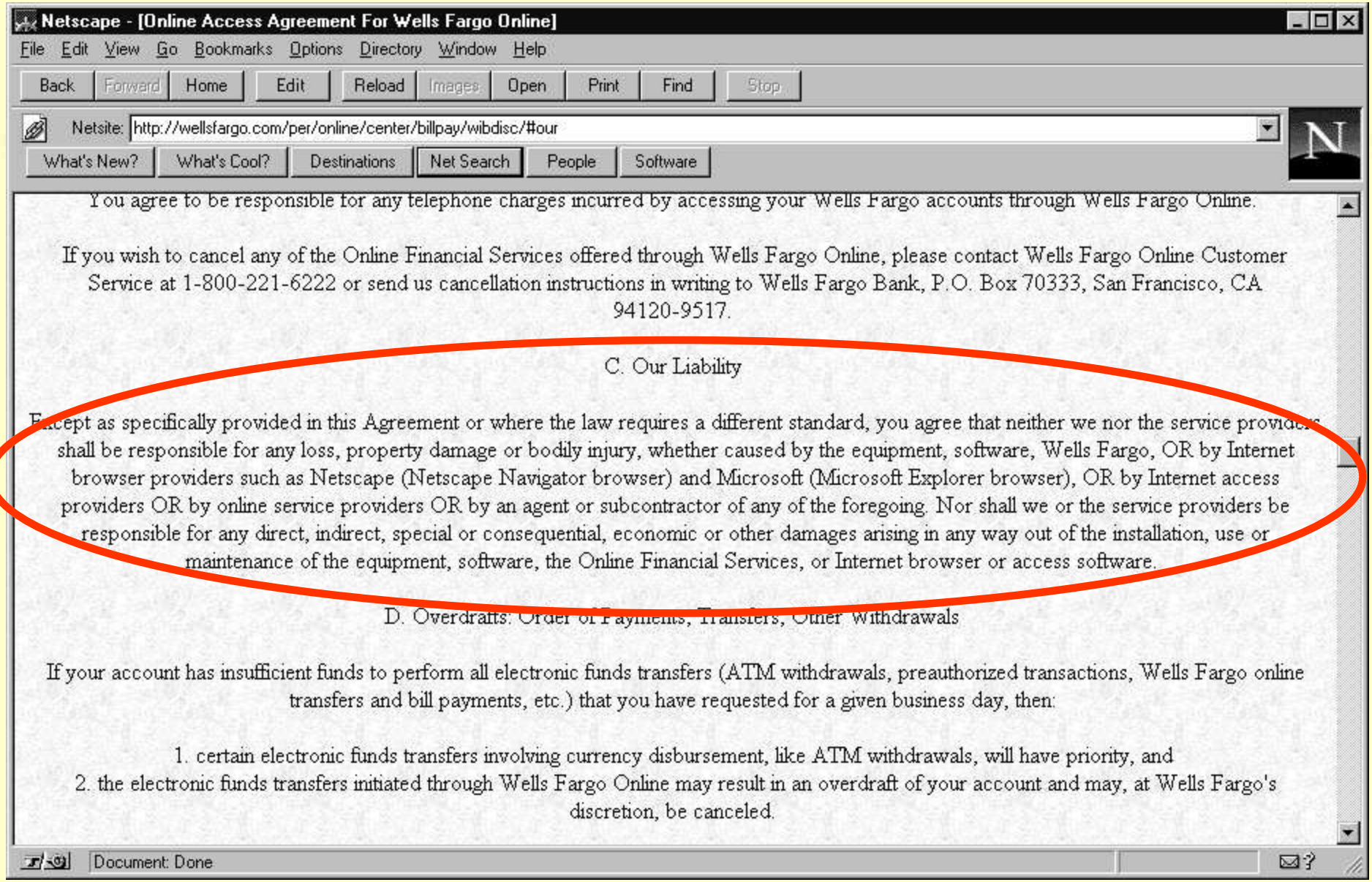
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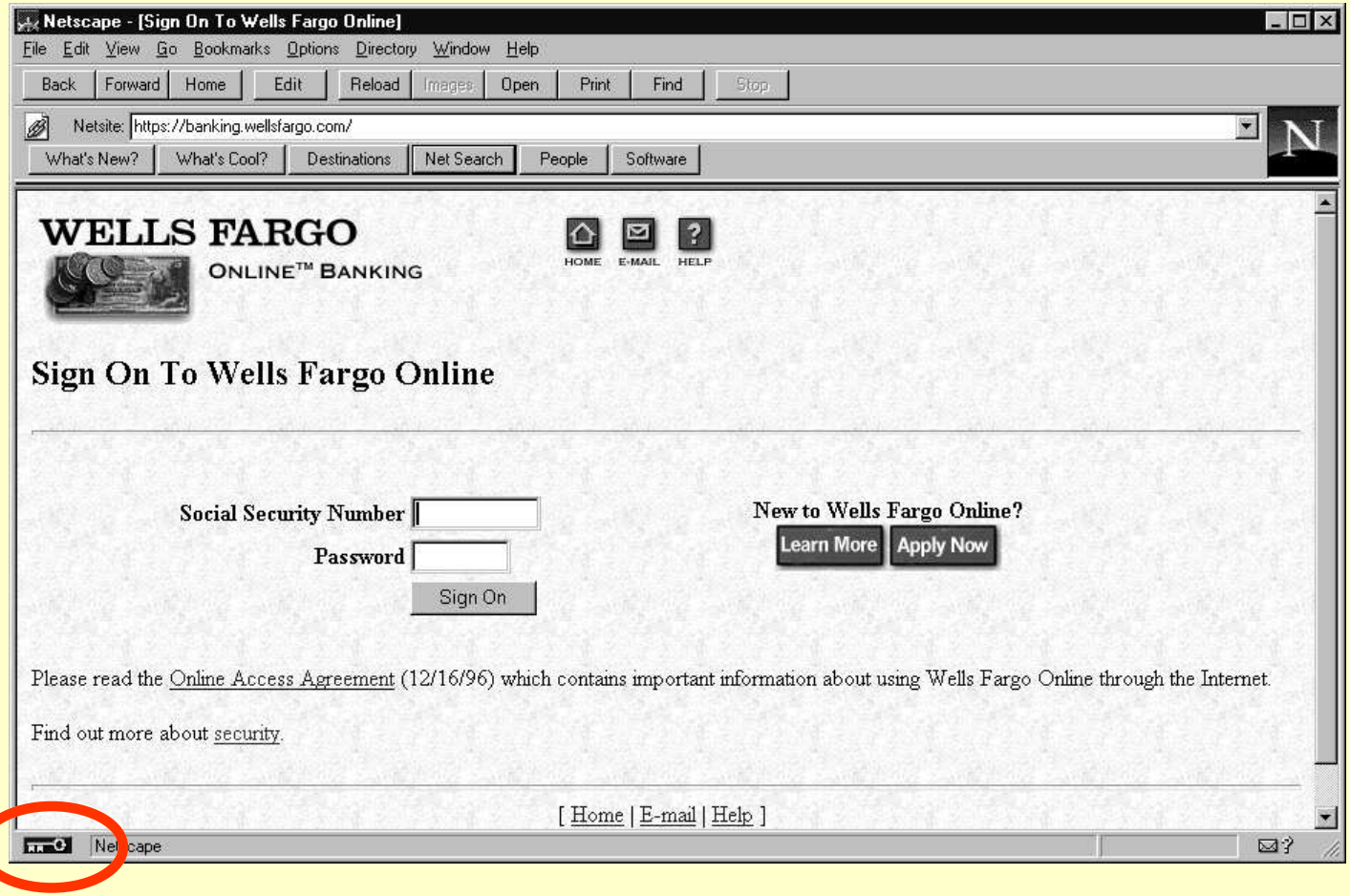
Secure Browser Interaction



Basic Concepts

- Encryption scheme:

  encrypt(plaintext,key) decrypt(cyphertext,key^{-1})

- Secret vs. public key
  - Public key: publishing key does not reveal key $^{-1}$
  - Secret key: more efficient; can have key = key $^{-1}$
- Hash function

  map long text to short hash key; ideally, no collision
- Signature scheme

  public key^{-1} and private key provide “authentication”

Establishing Secure Communication

- Parties use protocol to
  - choose encryption scheme, e.g.
    - 40-bit international encryption with 2^{40} keys
    - 120-bit domestic encryption with 2^{120} keys
    - choose among versions of specific scheme
  - agree on shared secret key
    - Secret key more efficient than public key
    - Minimize reuse of hard-to-establish public key

Secure Socket Layer (*SSL*)

- Three goals
  - Negotiate specific encryption scheme
    - Possible “version attack”
  - Authenticate client and server
    - Appeal to “signature authority”
  - Use public key to transmit secret key

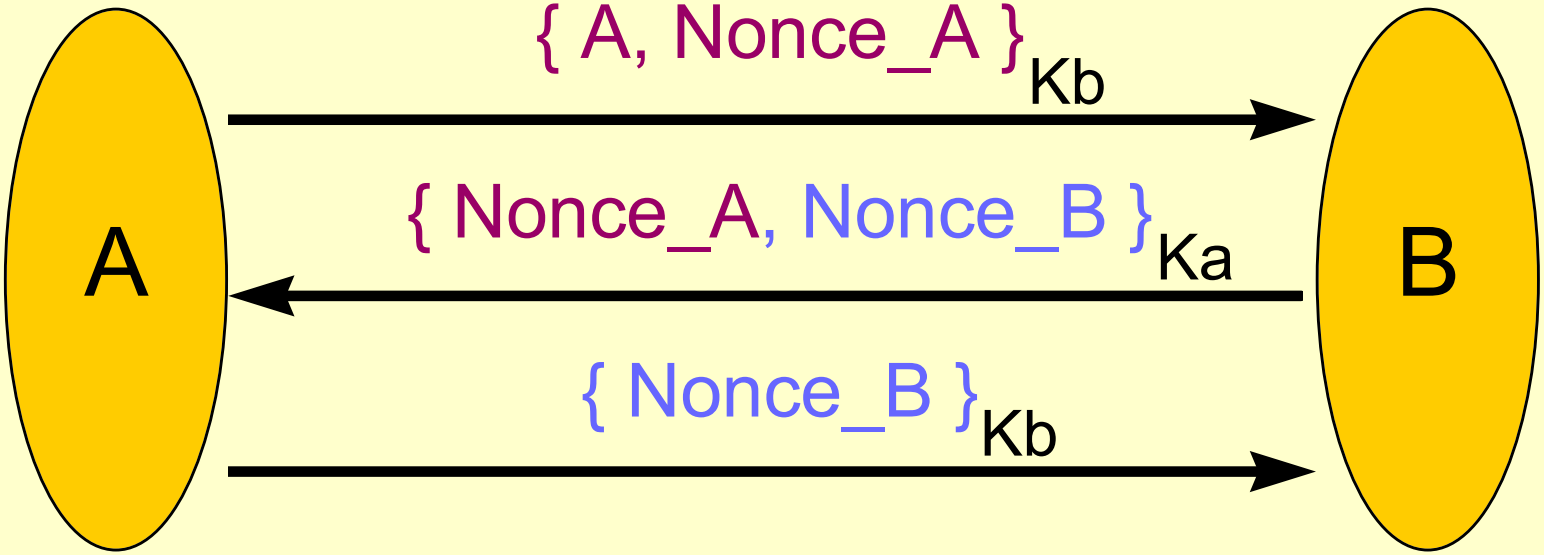
Several underlying primitives: public key, signature scheme, hash function, private key

Secure Socket Layer (*SSL)*

- Three steps in protocol
  - Client requests connection with server
  - Server responds, sends public key
  - Client sends encrypted private session key, hash of messages to avoid tampering

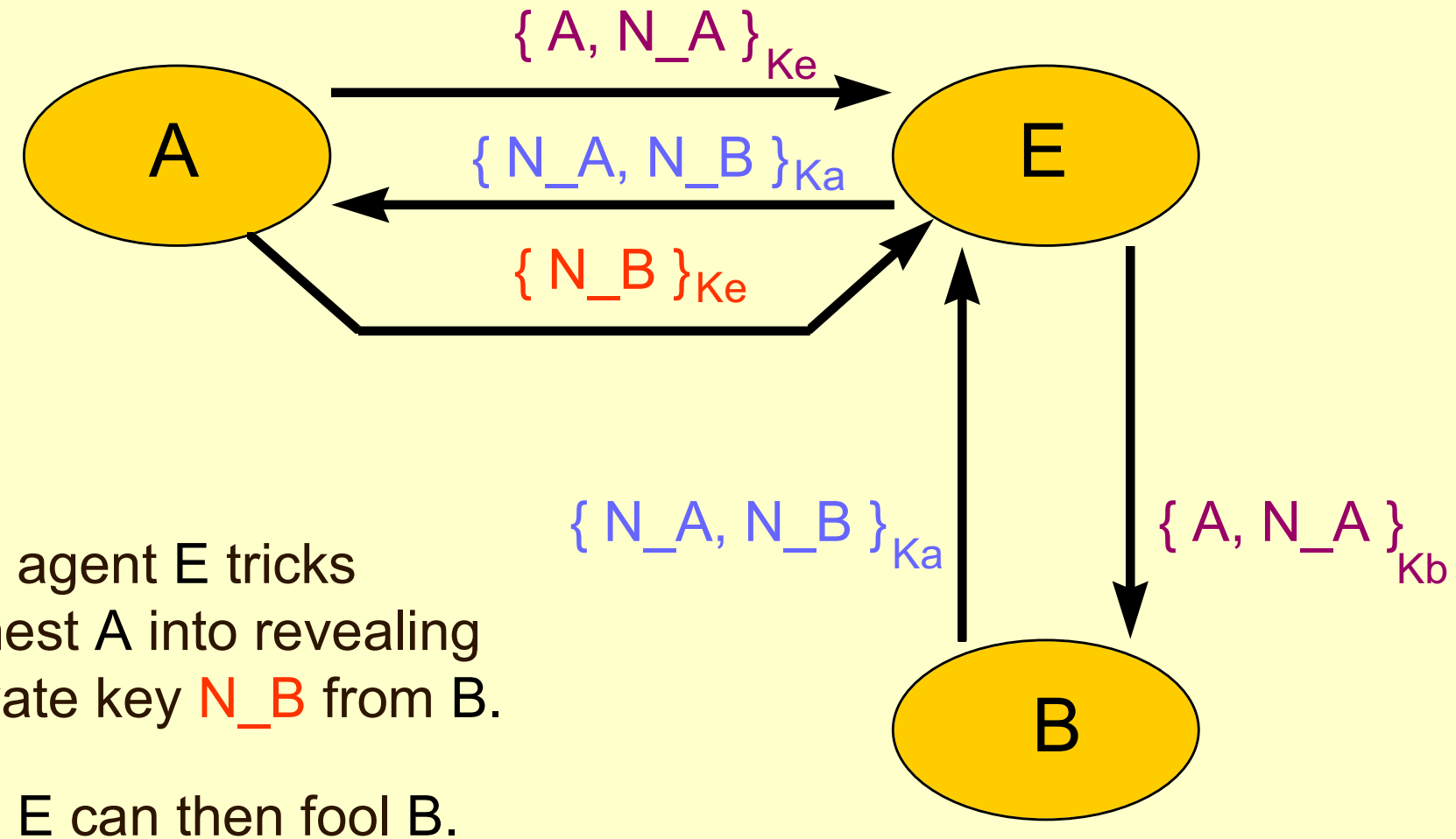
Illustrate basic concept, difficulties using Needham-Schroeder key exchange

Needham-Schroeder Key Exchange



Result: A and B share two private numbers not known to any observer without Ka^{-1}, Kb^{-1}

Anomaly in Needham-Schroeder



Evil agent E tricks honest A into revealing private key N_B from B.

Evil E can then fool B.

Analyzing Security Protocols

- Think long and hard
- BAN Logic
- Logic-based tools
- Exhaustive state-enumeration tools

Murφ [Dill et al.]

- Describe finite-state system
  - *Startstate* declaration
  - Transition rules
  - Correctness conditions
- Scalable: choose system size parameters
- Automatic exhaustive testing

  space limit: hash table to avoid repeated states

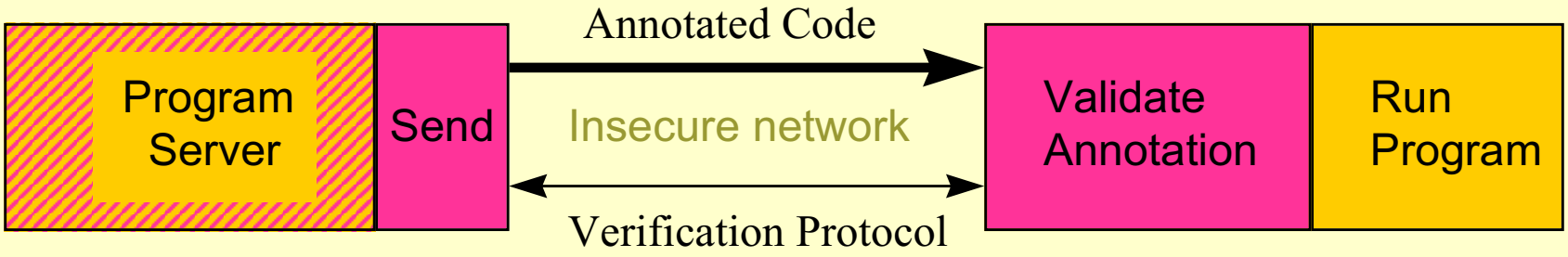
Murφ for security protocols

- Formulate protocol
- Add adversary
  - Control over "network" (shared variables)
  - Possible actions
    - Intercept any message
    - Remember parts of messages
    - Generate new messages, using observed data and initial knowledge (e.g. public keys)
- Identify correctness conditions

Murφ Results [1997]

- Analyze common protocols
  - Needham-Schroeder
  - Kerberos
    - Found bug in documented algorithm
    - one client, two servers
  - TMN cellular phone protocol
    - Found all known bugs automatically
    - Model algebraic properties of encryption function
- Work in progress: SSL protocol

Network Software Distribution



- Annotate programs with critical information
- Receiver checks annotations
  - on arrival, possibly by dialog with sender
  - during execution, possibly probabilistically
- Minimize exposure to severe risks

Other Security Work in Department

- Cheriton, Greenwald, et al.
  - Stanford University Research Firewall (SURF):
  - trade off information transfer vs information security
- Luckham, Meldal, et al.
  - modeling the MISSI security policies in Rapide
- Roscheisen (Digital Libraries)
  - Contract-based Rights Management
- Wiederhold
  - Trusted Interoperation of Healthcare Information (TIHI)
- Others?