CSE 484 / CSE M 584: Computer Security and Privacy

Web Security: SSL/TLS

Spring 2015

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Thanks to Dan Boneh, Dieter Gollmann, Dan Halperin, Yoshi Kohno, John Manferdelli, John Mitchell, Vitaly Shmatikov, Bennet Yee, and many others for sample slides and materials ...

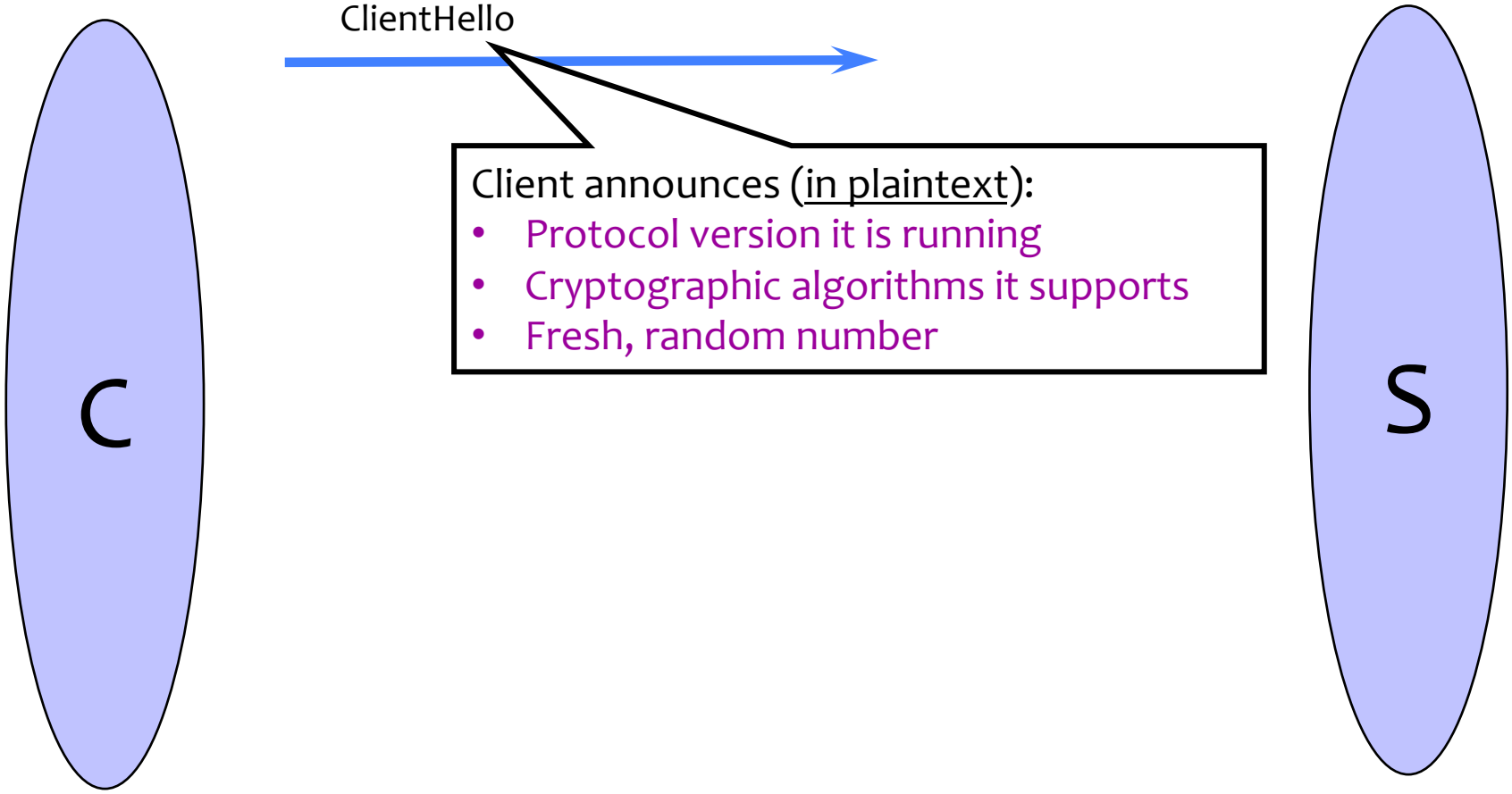
SSL/TLS: More Details

- Secure Sockets Layer and Transport Layer Security protocols
  - Same protocol design, different crypto algorithms
- De facto standard for Internet security
  - "The primary goal of the TLS protocol is to provide privacy and data integrity between two communicating applications"
- Deployed in every Web browser; also VoIP, payment systems, distributed systems, etc.

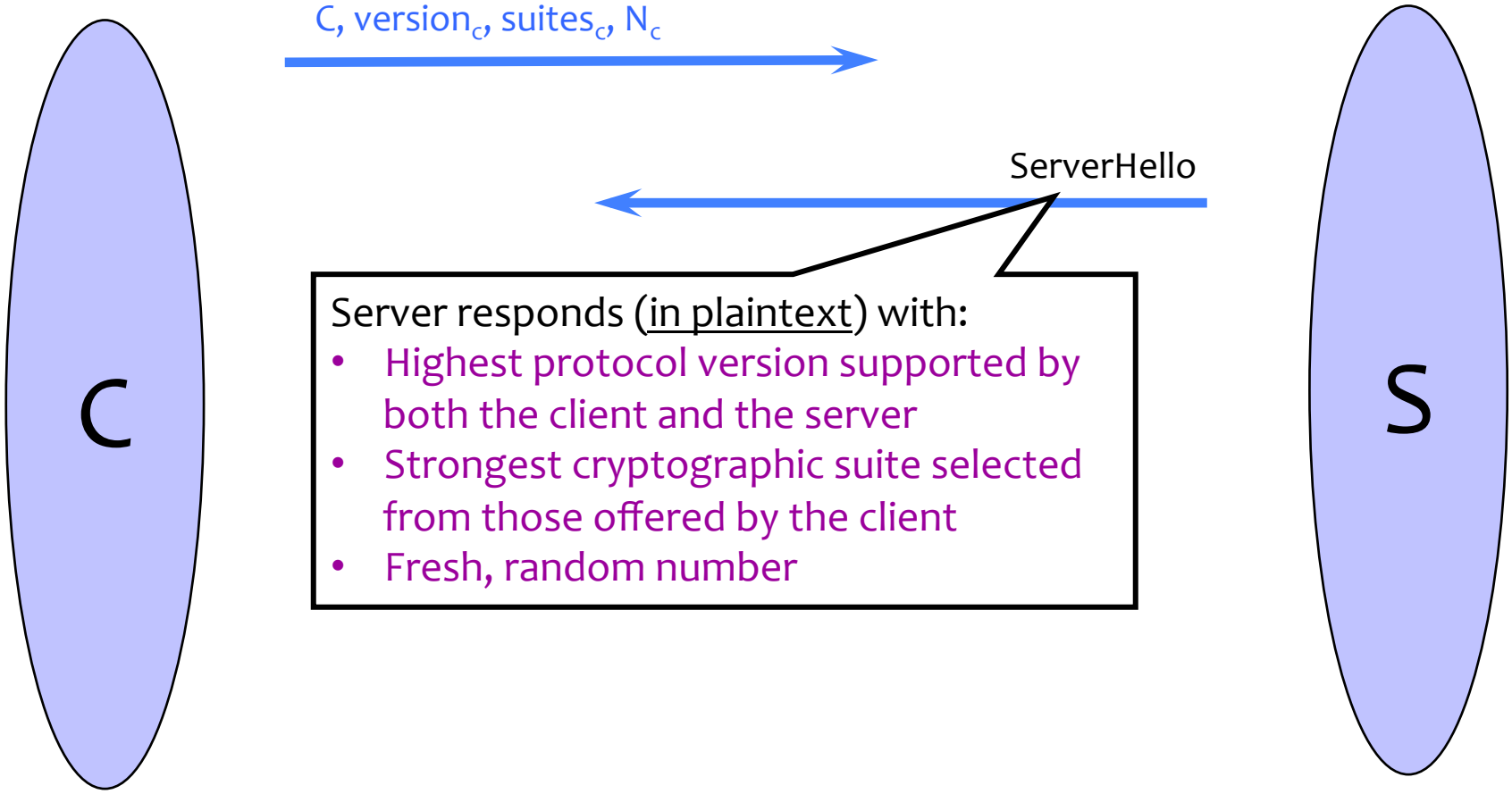
TLS Basics

- 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

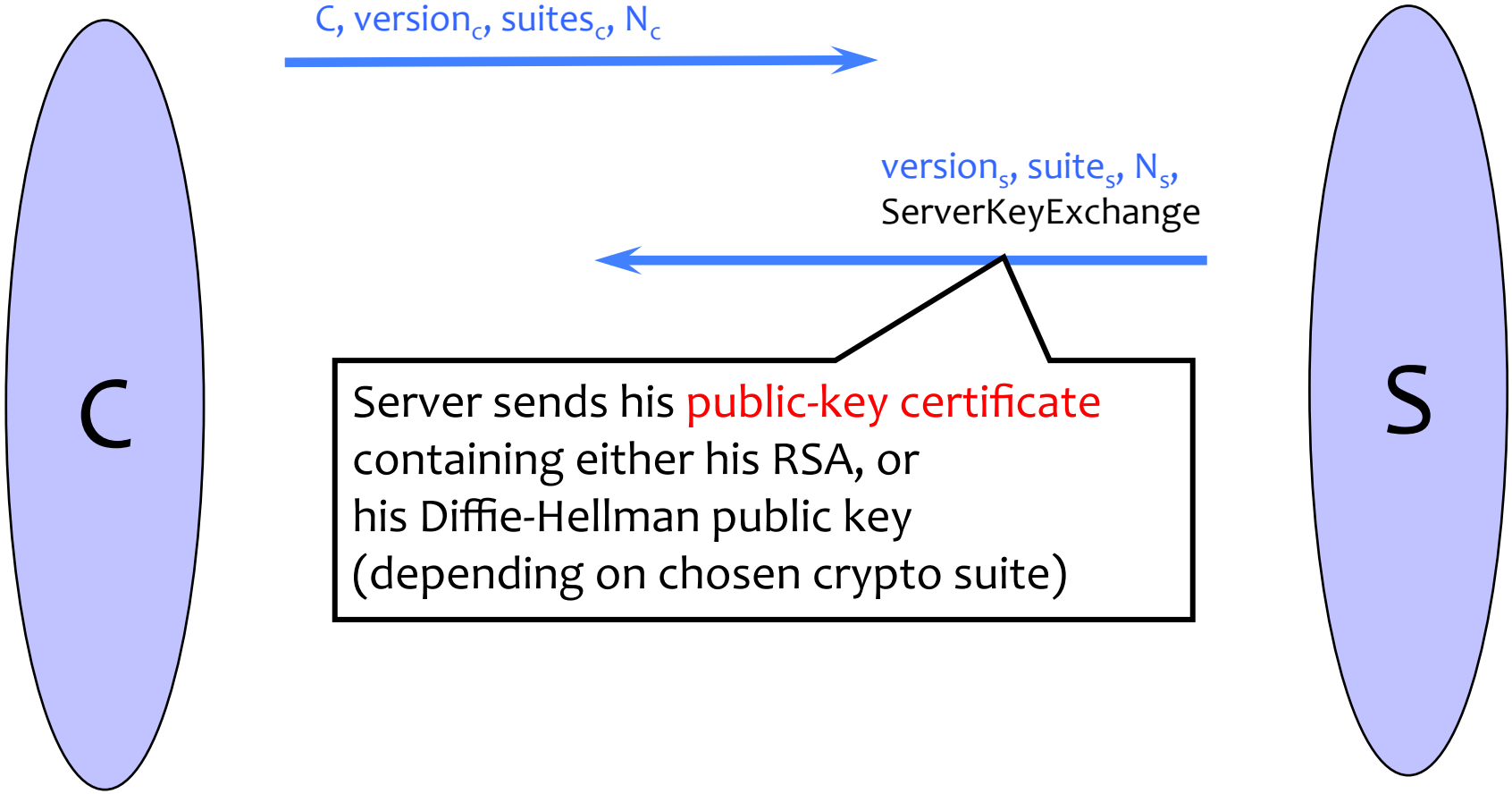
Basic Handshake Protocol



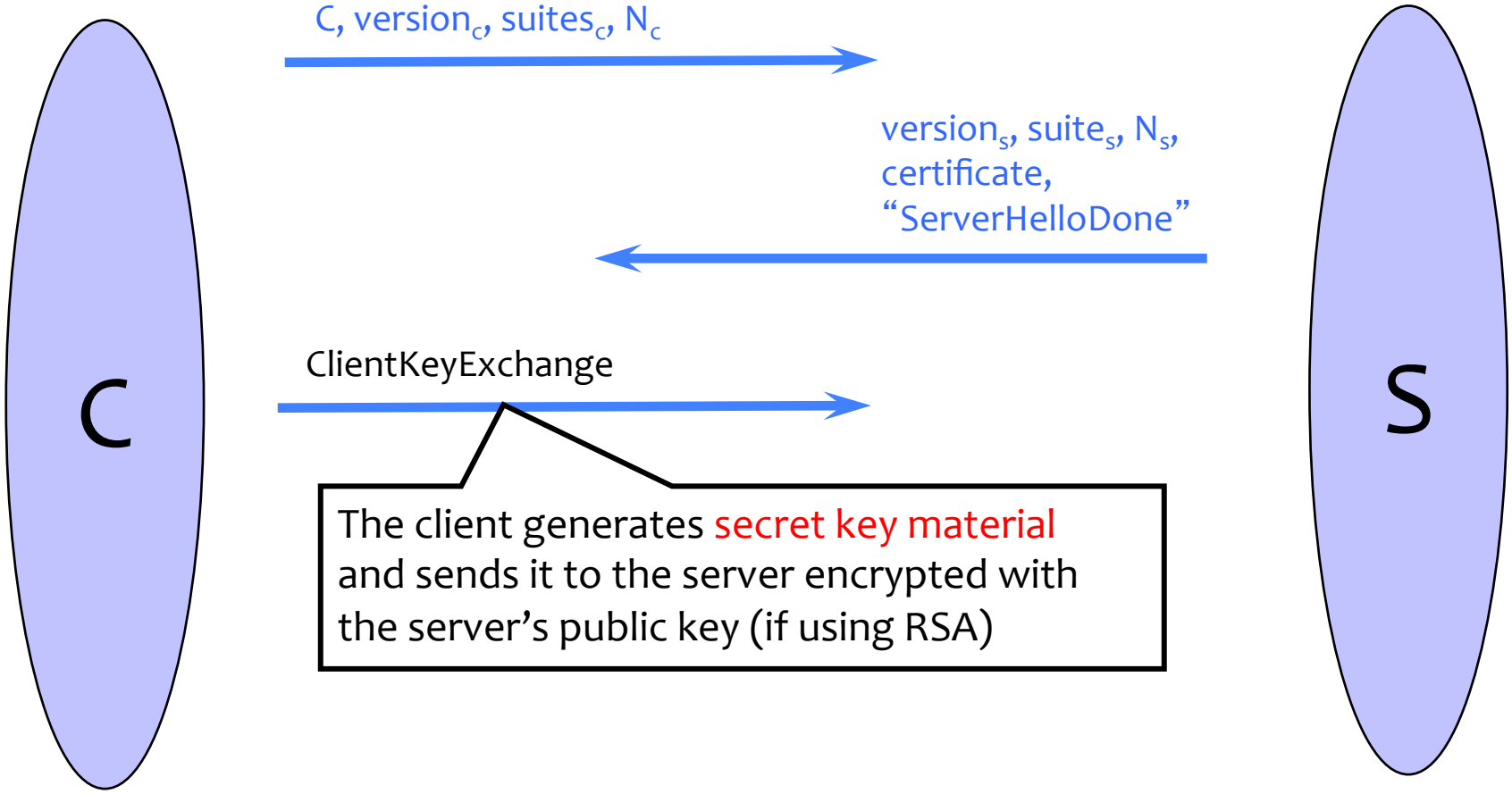
Basic Handshake Protocol



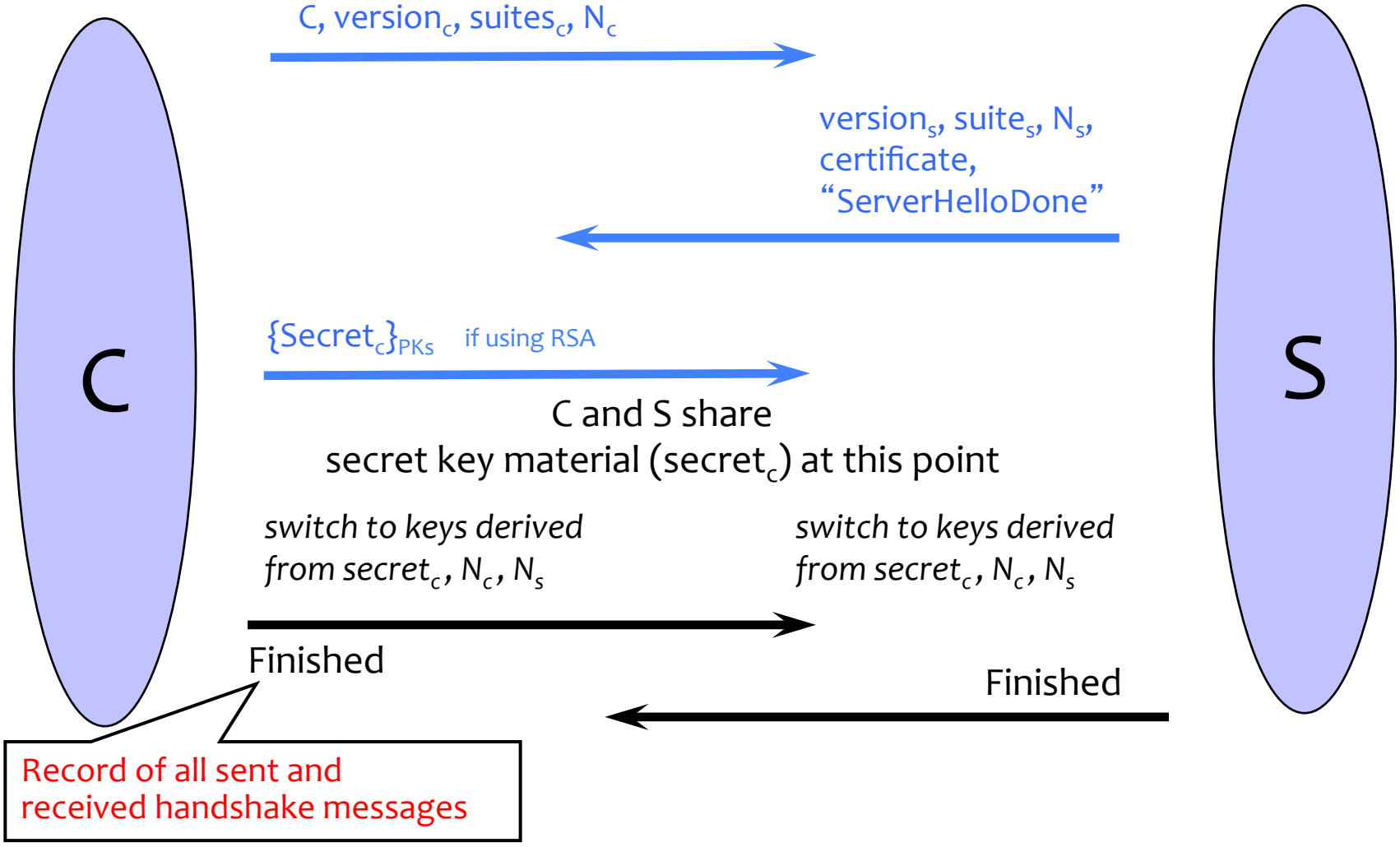
Basic Handshake Protocol



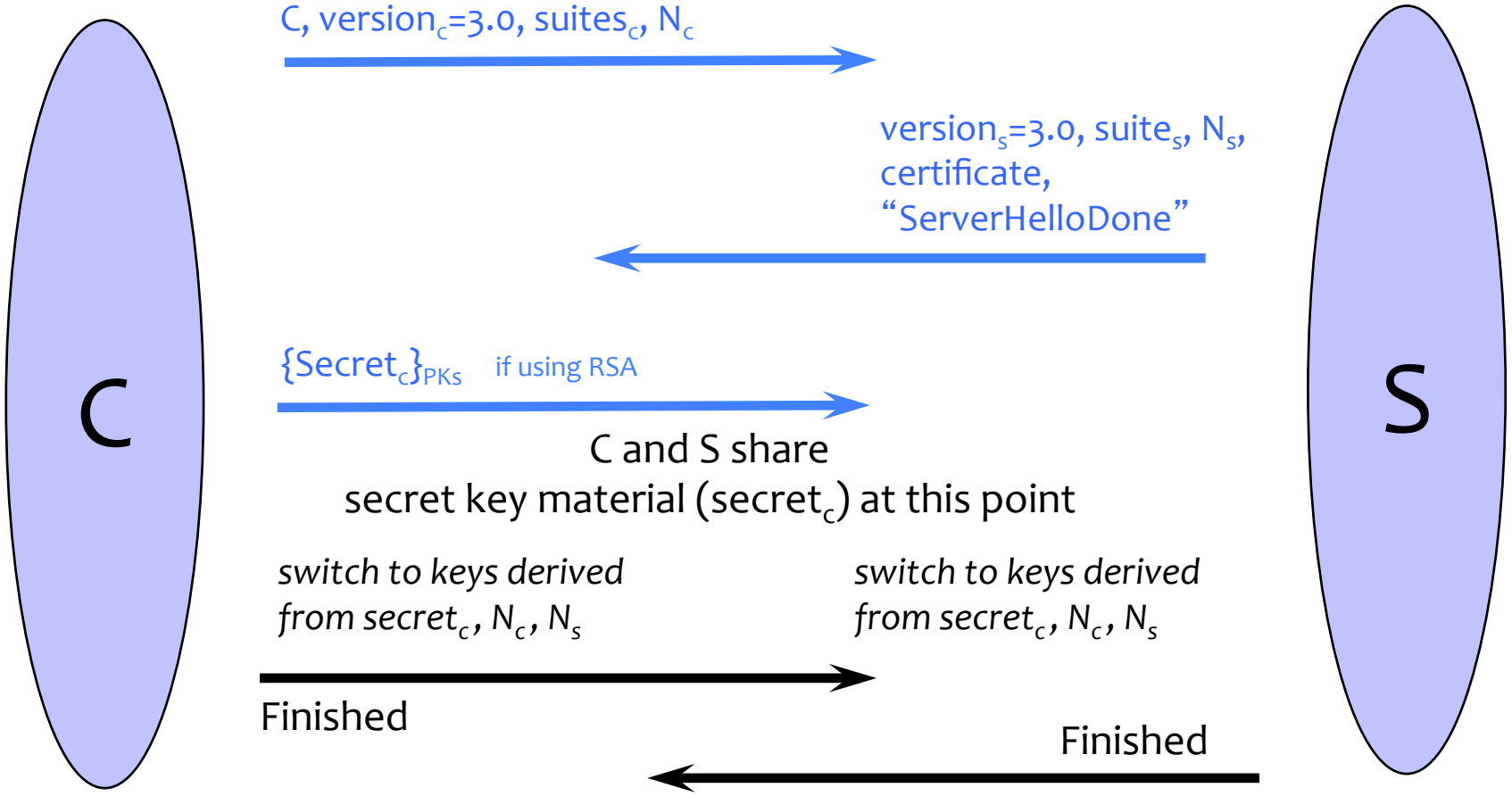
Basic Handshake Protocol



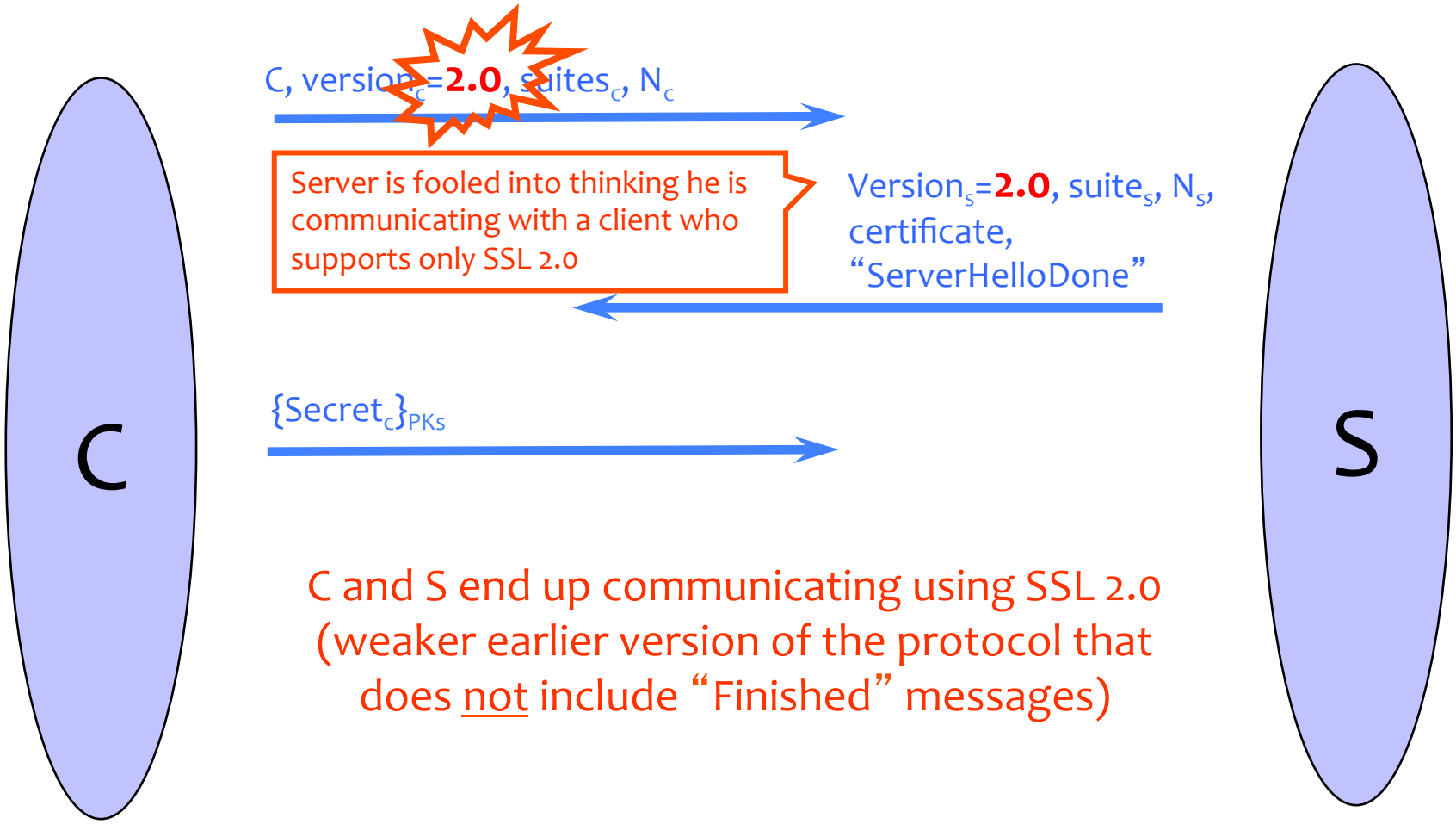
Basic Handshake Protocol



"Core" SSL 3.0 Handshake



Version Rollback Attack

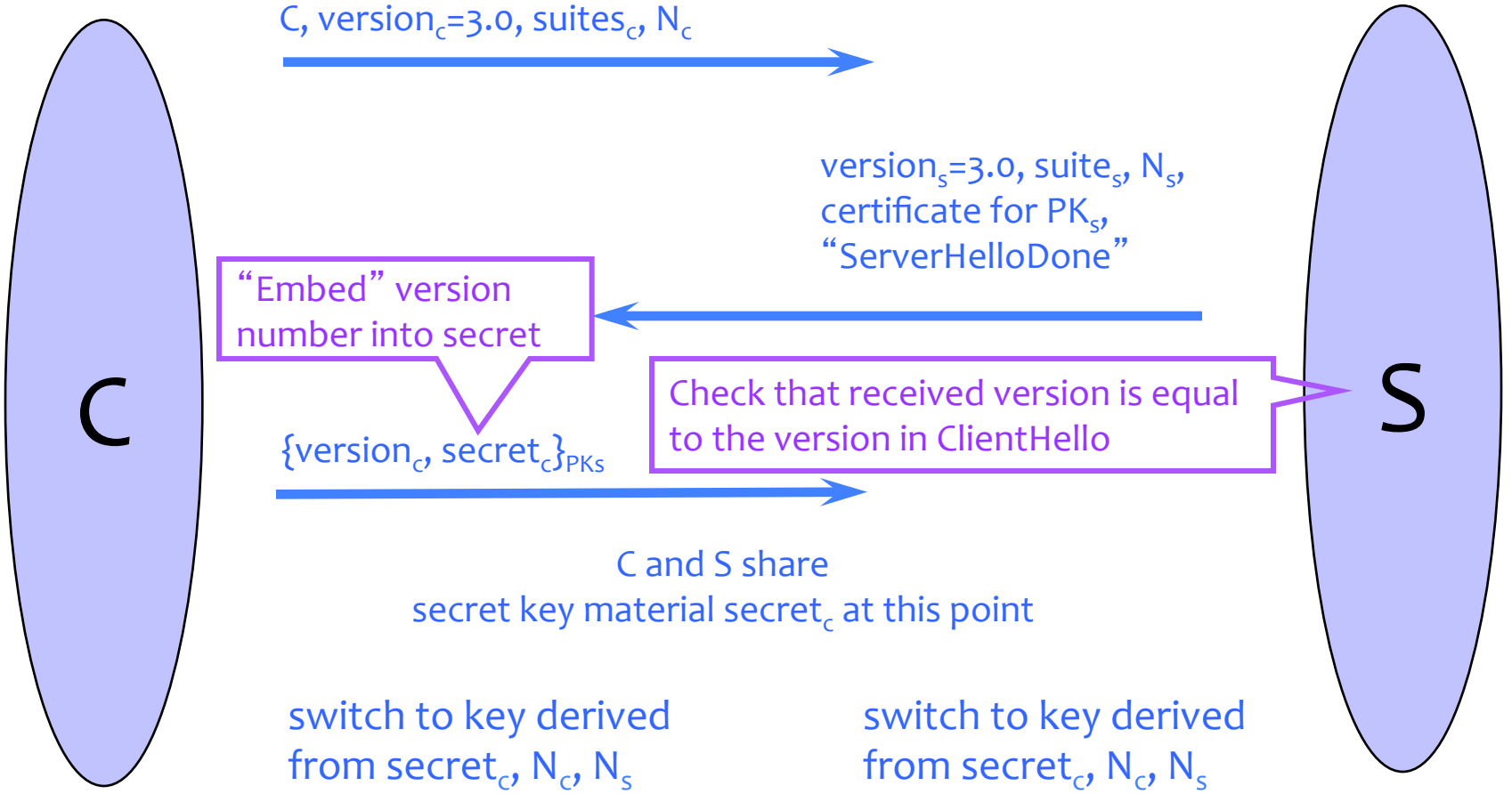


C and S end up communicating using SSL 2.0 (weaker earlier version of the protocol that does not include "Finished" messages)

"Chosen-Protocol" 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



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Web Security: Basic Web Security Model

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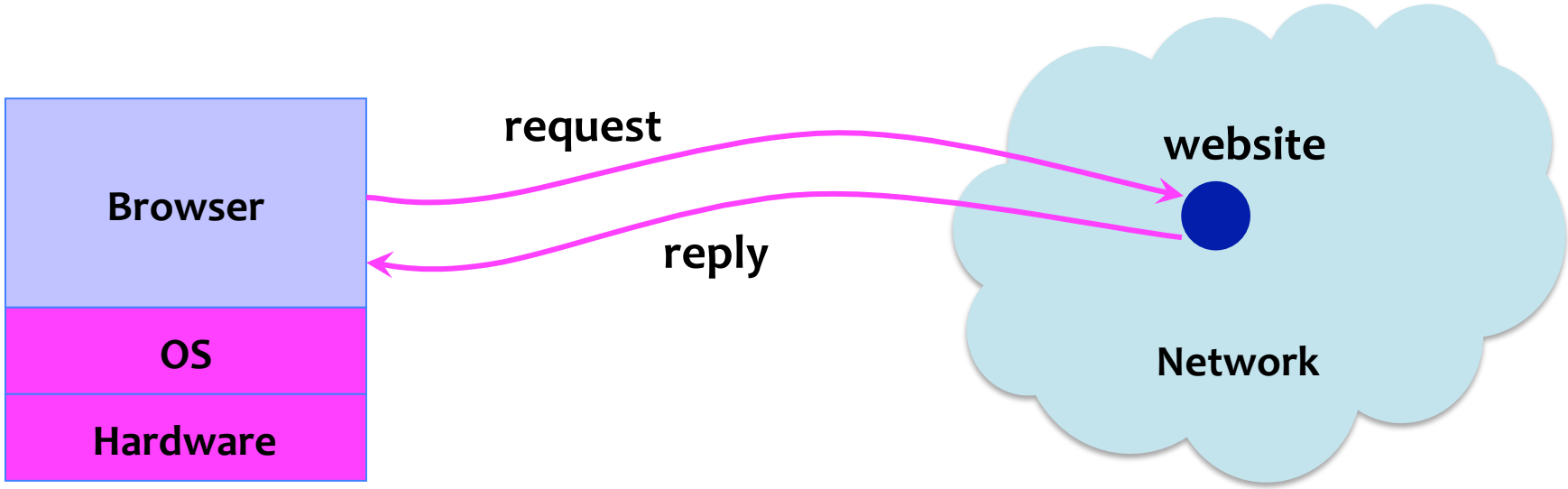
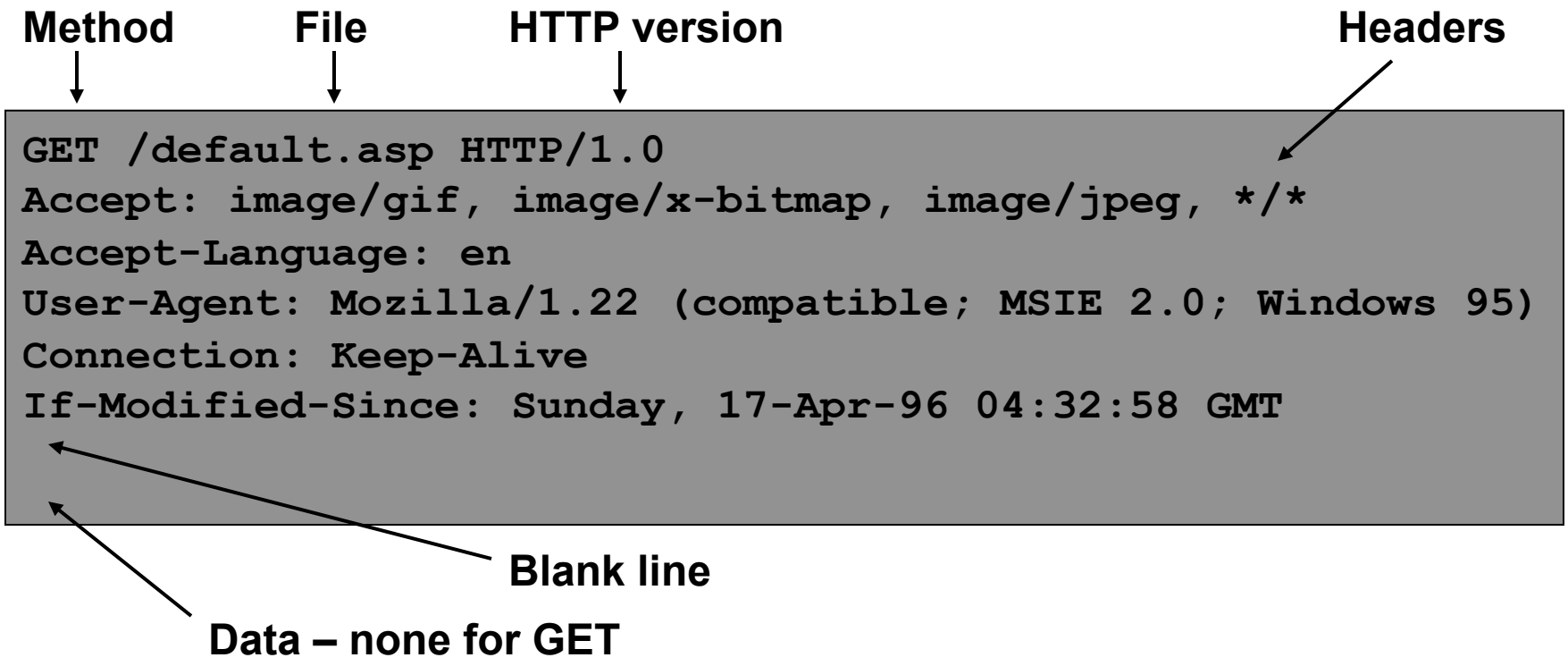
Browser and Network



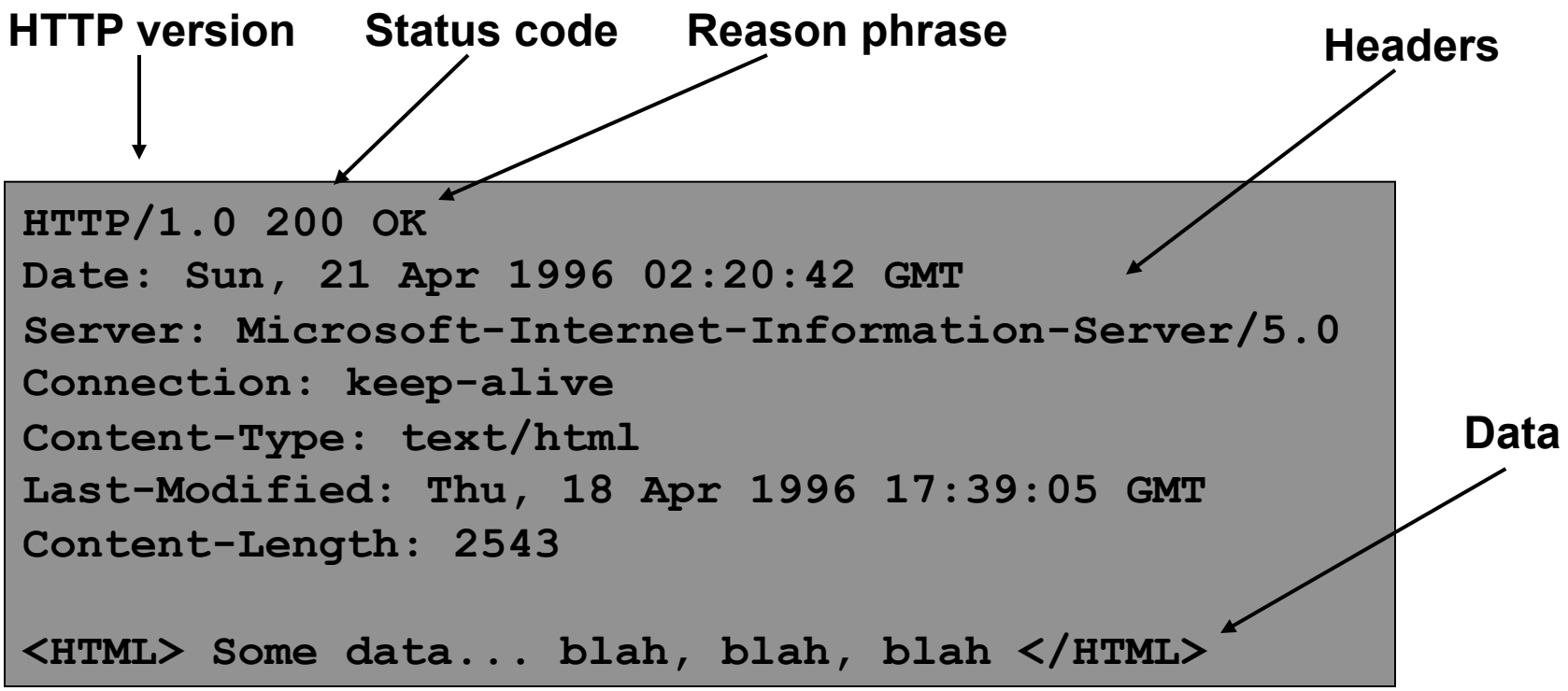
HTTP: HyperText Transfer Protocol

- Used to request and return data
  - Methods: GET, POST, HEAD, …
- Stateless request/response protocol
  - Each request is independent of previous requests
  - Statelessness has a significant impact on design and implementation of applications
- Evolution
  - HTTP 1.0: simple
  - HTTP 1.1: more complex

HTTP Request

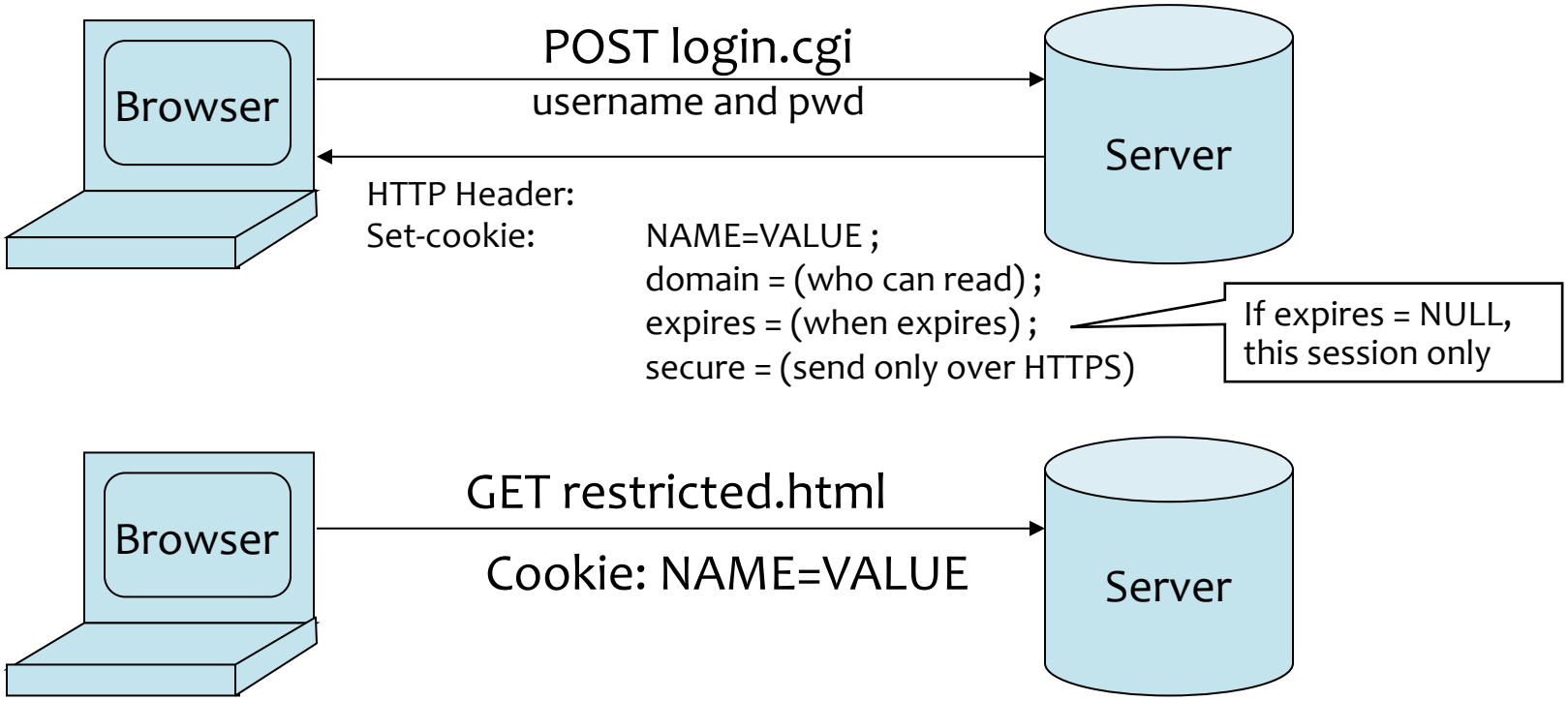


HTTP Response



Websites Storing Info in Browser

A cookie is a file created by a website to store information in the browser



HTTP is a stateless protocol; cookies add state

What Are Cookies Used For?

- Authentication
  - The cookie proves to the website that the client previously authenticated correctly
- Personalization
  - Helps the website recognize the user from a previous visit
- Tracking
  - Follow the user from site to site; learn his/her browsing behavior, preferences, and so on

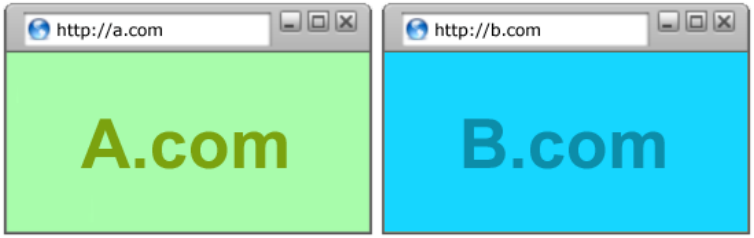
Goals of Web Security

- Safely browse the Web
  - A malicious website cannot steal information from or modify legitimate sites or otherwise harm the user…
  - … even if visited concurrently with a legitimate site - in a separate browser window, tab, or even iframe on the same webpage
- Support secure Web applications
  - Applications delivered over the Web should have the same security properties we require for standalone applications

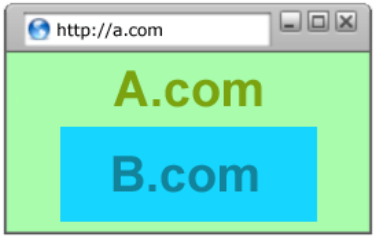
All of These Should Be Safe

- Safe to visit an evil website

- Safe to visit two pages at the same time

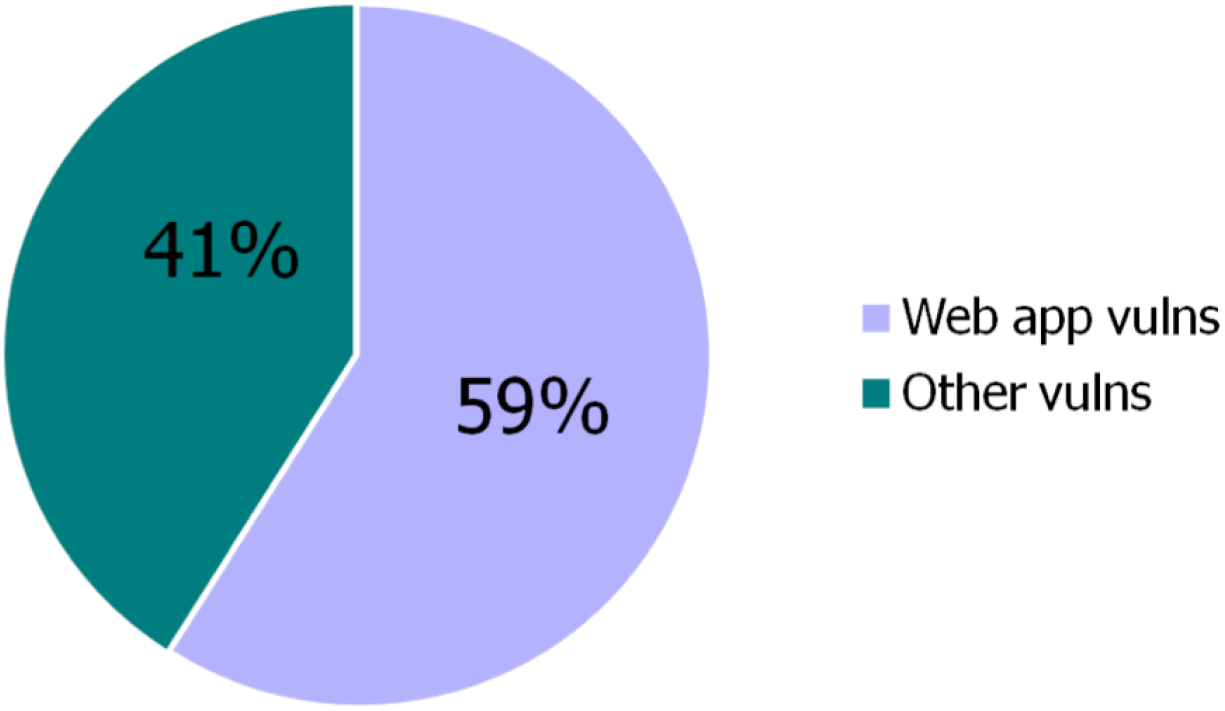


- Safe delegation



Security Vulnerabilities in 2011

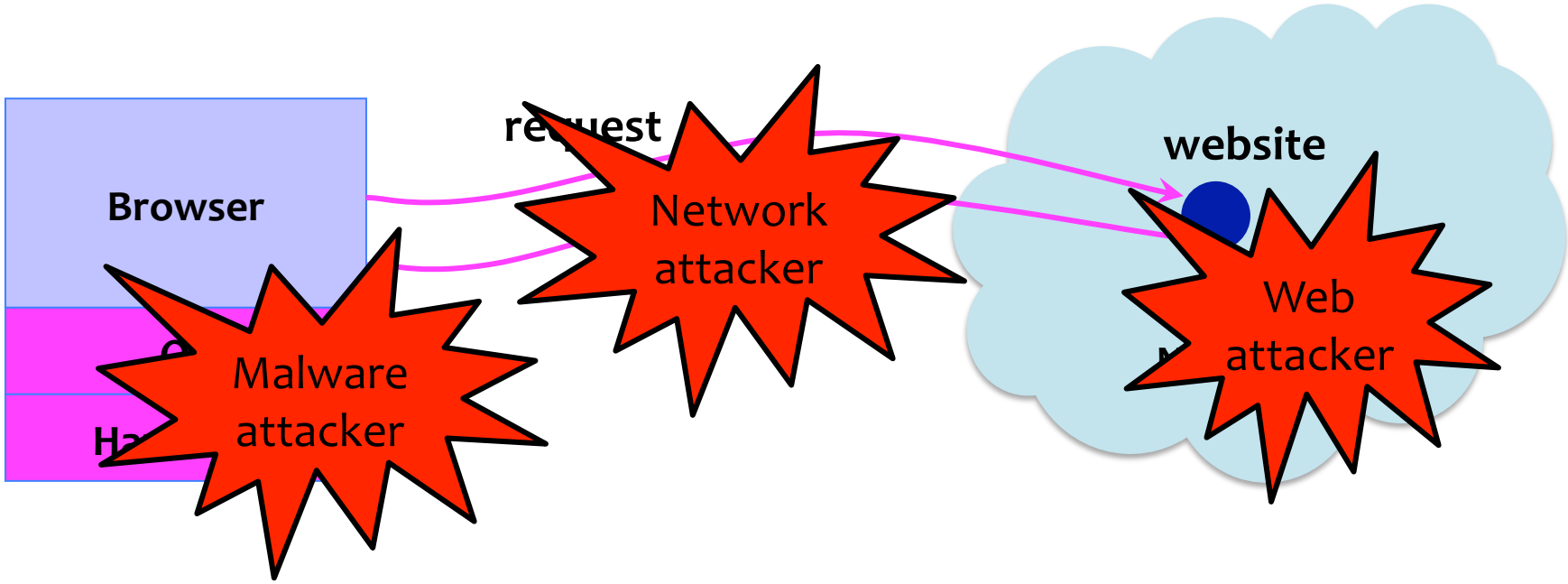
Source: IBM X-Force



Two Sides of Web Security

- Web browser
  - Responsible for securely confining Web content presented by visited websites
- Web applications
  - Online merchants, banks, blogs, Google Apps …
  - Mix of server-side and client-side code
    - Server-side code written in PHP, Ruby, ASP, JSP… runs on the Web server
    - Client-side code written in JavaScript… runs in the Web browser
  - Many potential bugs: XSS, XSRF, SQL injection

Where Does the Attacker Live?



Web Attacker

- Controls a malicious website (attacker.com)
  - Can even obtain an SSL/TLS certificate for his site
- User visits attacker.com – why?
  - Phishing email, enticing content, search results, placed by an ad network, blind luck …
- Attacker has no other access to user machine!
- Variation: "iframe attacker"
  - An iframe with malicious content included in an otherwise honest webpage
    - Syndicated advertising, mashups, etc.

HTML and JavaScript

Browser receives content,
displays HTML and executes scripts

```
<html>
      …
<p> The script on this page adds two numbers
<script>
   var num1, num2, sum
   num1 = prompt("Enter first number")
   num2 = prompt("Enter second number")
   sum = parseInt(num1) + parseInt(num2)
   alert("Sum = " + sum)
</script>
   …
</html>
```

A potentially malicious webpage gets to execute some code on user's machine!

Browser Sandbox

- Goal: safely execute JavaScript code provided by a website
  - No direct file access, limited access to OS, network, browser data, content that came from other websites
- Same origin policy
  - Can only access properties of documents and windows from the same domain, protocol, and port