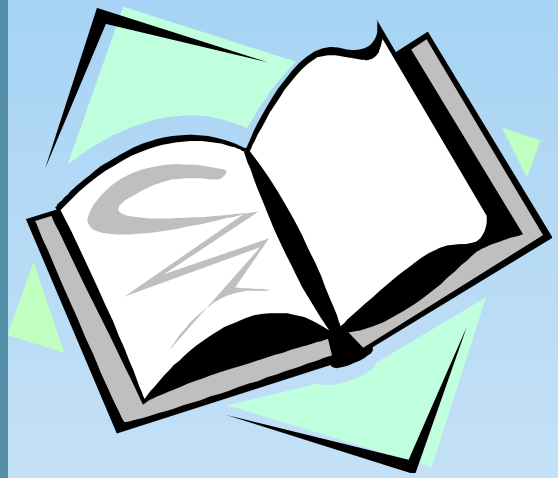
Cookies

Readings for This Lecture

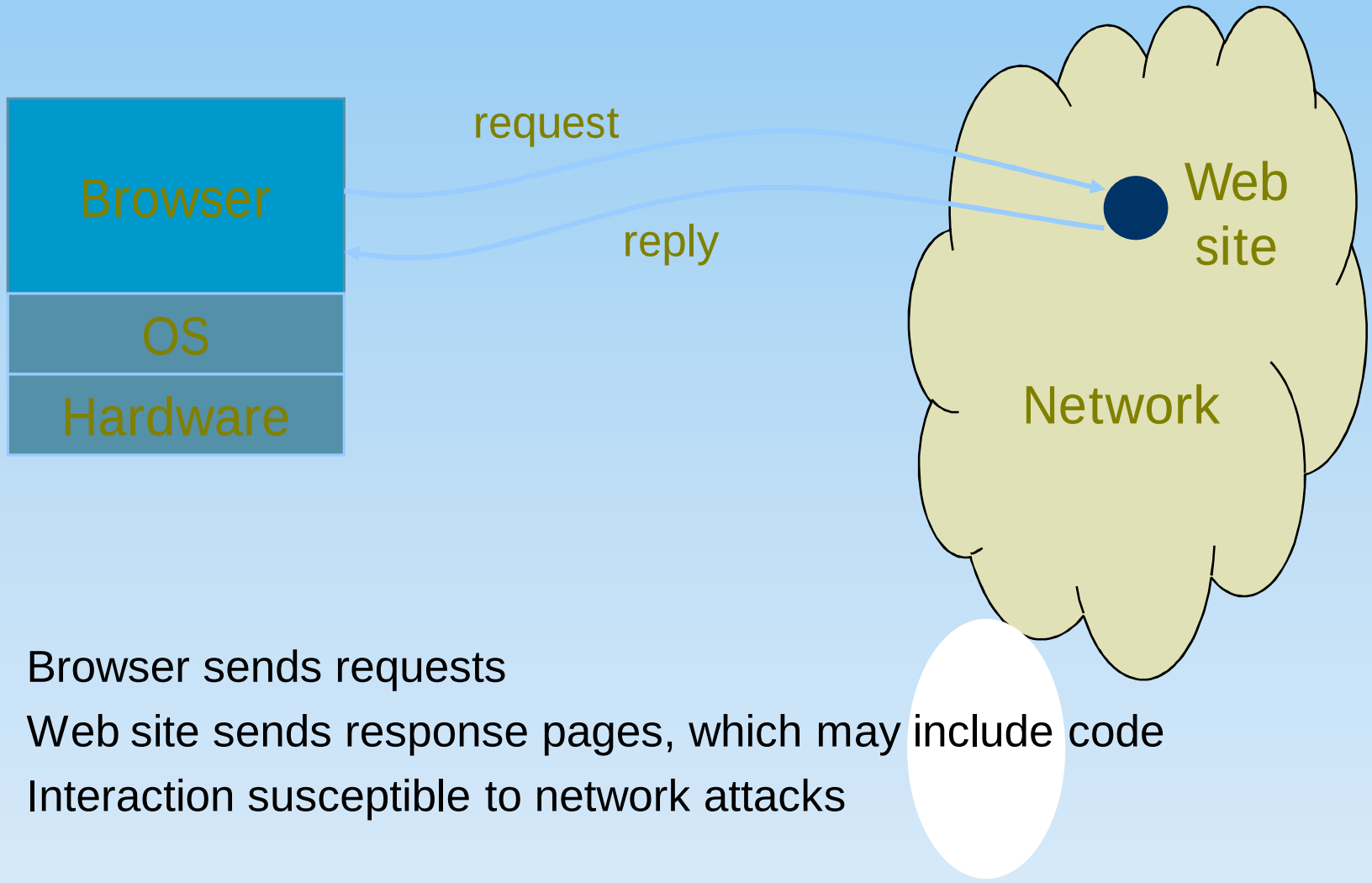
- Wikipedia
  - HTTP Cookie
  - Same Origin Policy
  - Cross Site Scripting
  - Cross Site Request Forgery



Background

- Many sensitive tasks are done through web
  - Online banking, online shopping
  - Database access
  - System administration
- Web applications and web users are targets of many attacks
  - Cross site scripting
  - SQL injection
  - Cross site request forgery
  - Information leakage
  - Session hijacking

Web Browser and Network



- Browser sends requests
- Web site sends response pages, which may include code
- Interaction susceptible to network attacks

Web Security Issues

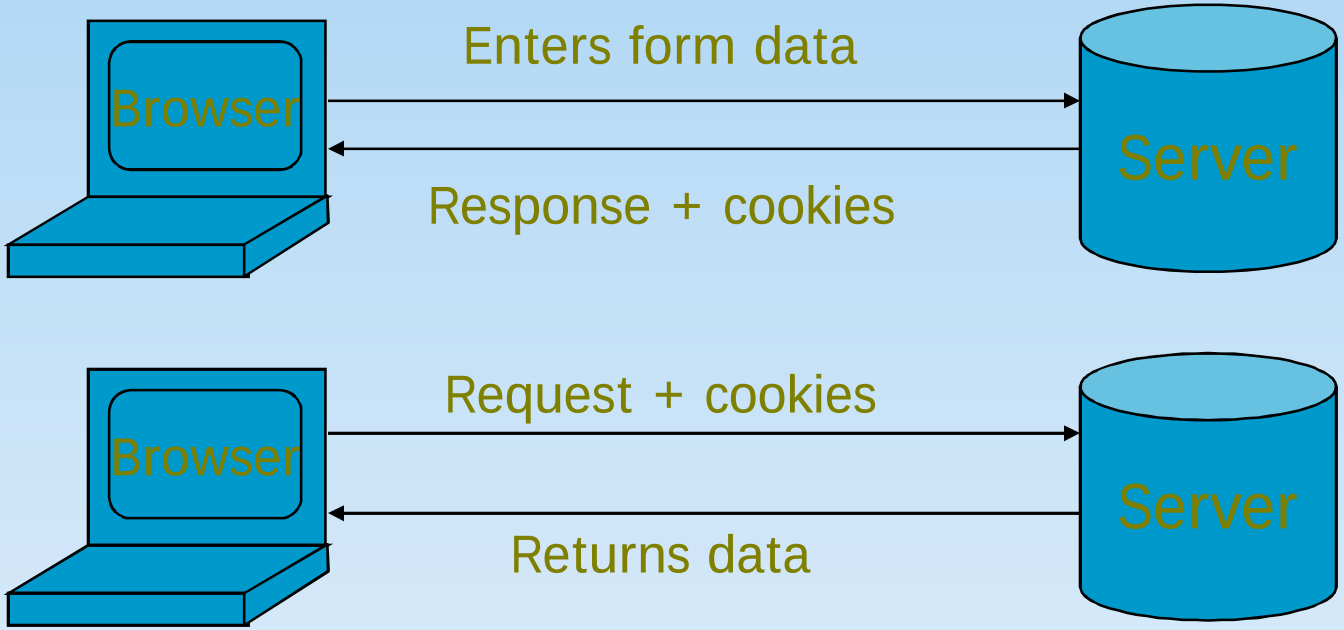
- Secure communications between client & server
  - HTTPS (HTTP over SSL)
- User authentication & session management
  - Cookies & other methods
- Active contents from different websites
  - Protecting resources maintained by browsers
- Web application security
- Web site authentication (e.g., anti-phishing)
- Privacy concerns

HTTP: HyperText Transfer Protocol

- Browser sends HTTP requests to the server
  - Methods: GET, POST, HEAD, …
  - GET: to retrieve a resource (html, image, script, css,…)
  - POST: to submit a form (login, register, …)
  - HEAD
- Server replies with a HTTP response
- Stateless request/response protocol
  - Each request is independent of previous requests
  - Statelessness has a significant impact on design and implementation of applications

Use Cookies to Store State Info

- Cookies
  - A cookie is a name/value pair created by a website to store information on your computer



Http is stateless protocol; cookies add state

Cookies Fields

- An example cookie
  - Name session-token
  - Content "s7yZiOvFm4YymG….”
  - Domain .amazon.com
  - Path /
  - Send For Any type of connection
  - Expires Monday, September 08, 2031 7:19:41 PM

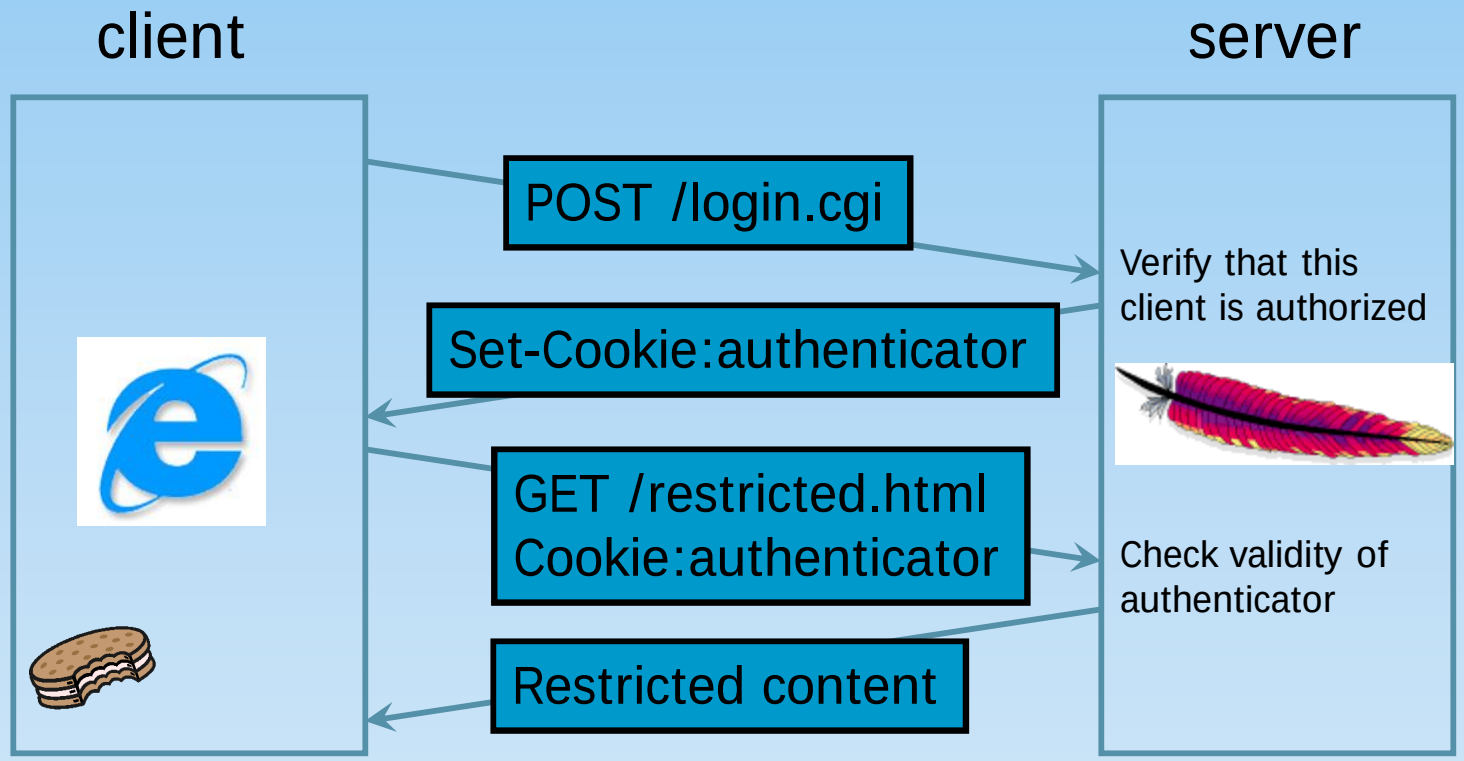
Cookies

- Stored by the browser
- Used by the web applications
  - used for authenticating, tracking, and maintaining specific information about users
    - e.g., site preferences, contents of shopping carts
  - data may be sensitive
  - may be used to gather information about specific users
- Cookie ownership
  - Once a cookie is saved on your computer, only the website that created the cookie can read it

Web Authentication via Cookies

- HTTP is stateless
  - How does the server recognize a user who has signed in?
- Servers can use cookies to store state on client
  - After client successfully authenticates, server computes an authenticator and gives it to browser in a cookie
    - Client cannot forge authenticator on his own (session id)
  - With each request, browser presents the cookie
  - Server verifies the authenticator

A Typical Session with Cookies



Authenticators must be unforgeable and tamper-proof

(malicious clients shouldn't be able to modify an existing authenticator)

How to design it?

Cross Site Scripting

Client Side Scripting

- Web pages (HTML) can embed dynamic contents (code) that can executed on the browser

- JavaScript
  - embedded in web pages and executed inside browser
- VBScript
  - similar to JavaScript, only for Windows
- Java applets
  - small pieces of Java bytecodes that execute in browsers

HTML and Scripting

```
<html>
    …
   <P>
<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>
```

Browser receives content, displays HTML and executes scripts

Scripts are Powerful

- Client-side scripting is powerful and flexible, and can access the following resources
  - Local files on the client-side host
    - read / write local files
  - Webpage resources maintained by the browser
    - Cookies
    - Domain Object Model (DOM) objects
      - steal private information
      - control what users see
      - impersonate the user

Browser as an Operating System

- Web users visit multiple websites simultaneously
- A browser serves web pages (which may contain programs) from different web domains
  - i.e., a browser runs programs provided by mutually untrusted entities
  - Running code one does not know/trust is dangerous
  - A browser also maintains resources created/updated by web domains
- Browser must confine (sandbox) these scripts so that they cannot access arbitrary local resources
- Browser must have a security policy to manage/protect browser-maintained resources and to provide separation among mutually untrusted scripts

Same Origin Policy

- The basic security model enforced in the browser
- SoP isolates the scripts and resources downloaded from different origins
  - E.g., evil.org scripts cannot access bank.com resources
- Use origin as the security principal
- Origin = domain name + protocol + port
  - all three must be equal for origin to be considered the same

Security Principals

- A **security principal** is an entity that can be authenticated by a computer system or network.
  - Security principals, in addition to being able to be authenticated, are typically capable of being assigned rights and privileges over resources in the network.
- Unit to which information security policies can apply.
- Not to be confused with security principles.
- Choosing the right security principal is important.
- What are security principals in Unix?

Same Original Policy: What it Controls

- Same-origin policy applies to the following accesses:
  - manipulating browser windows
  - URLs requested via the XmlHttpRequest
    - XmlHttpRequest is an API that can be used by web browser scripting languages to transfer XML and other text data to and from a web server using HTTP, by establishing an independent and asynchronous communication channel.
      - used by AJAX
  - manipulating frames (including inline frames)
  - manipulating documents (included using the object tag)
  - manipulating cookies

Problems with S-O Policy

- Poorly enforced on some browsers
  - Particularly older browsers
- Limitations if site hosts unrelated pages
  - Example: Web server often hosts sites for unrelated parties
    - http://www.example.com/account/
    - http://www.example.com/otheraccount/
  - Same-origin policy allows script on one page to access properties of document from another
- Can be bypassed in Cross-Site-Scripting attacks

- Usability: Sometimes prevents desirable cross-origin resource sharing

Cross Site Scripting (XSS)

- Recall the basics
  - scripts embedded in web pages run in browsers
  - scripts can access cookies
    - get private information
  - and manipulate DOM objects
    - controls what users see
  - scripts controlled by the same-origin policy
- Why would XSS occur
  - Web applications often take user inputs and use them as part of webpage (these inputs can have scripts)

How XSS Works on Online Blog

- Everyone can post comments, which will be displayed to everyone who view the post
- Attacker posts a malicious comment that includes scripts (which reads local authentication credentials and send of to the attacker)
- Anyone who view the post can have local authentication cookies stolen
- Web apps will check that posts do not include scripts, but the check sometimes fail.
- Bug in the web application. Attack happens in browser.

Effect of the Attack

- Attacker can execute arbitrary scripts in browser
- Can manipulate any DOM component on victim.com
  - Control links on page
  - Control form fields (e.g. password field) on this page and linked pages.
- Can infect other users: MySpace.com worm.

MySpace.com (Samy worm)

- Users can post HTML on their pages
  - MySpace.com ensures HTML contains no
    `<script>, <body>, onclick, <a href=javascript://>`
  - However, attacker find out that a way to include Javascript within CSS tags:

```
<div style="background:url('javascript:alert(1)')">
```

  And can hide `"javascript"` as `"java\nscript"`
- With careful javascript hacking:
  - Samy's worm: infects anyone who visits an infected MySpace page … and adds Samy as a friend.
  - Samy had millions of friends within 24 hours.
- More info: http://namb.la/popular/tech.html

Avoiding XSS bugs (PHP)

- Main problem:
  - Input checking is difficult --- many ways to inject scripts into HTML.
- Preprocess input from user before echoing it
- PHP: **htmlspecialchars**(string)

  & → & " → " ' → '

  < → < > → >

  - **htmlspecialchars**(
    "Test", ENT_QUOTES);

    Outputs:

    Test

Avoiding XSS bugs (ASP.NET)

- ASP.NET 1.1:
  - **Server.HtmlEncode(string)**
    - Similar to PHP htmlspecialchars
  - validateRequest: (on by default)
    - Crashes page if finds <script> in POST data.
    - Looks for hardcoded list of patterns.
    - Can be disabled:

      <%@ Page validateRequest="false" %>

Cross site request forgery

Cross site request forgery (abbrev. CSRF or XSRF)

- **A**lso known as **one click attack** or **session riding**
- Transmits unauthorized commands from a user who has logged in to a website to the website.

CSRF Explained

- Example:
  - User logs in to bank.com. Forgets to sign off.
  - Session cookie remains in browser state
  - Then user visits another site containing:

```
<form name=F action=http://bank.com/BillPay.php>
<input name=recipient value=badguy> …
<script> document.F.submit(); </script>
```

  - Browser sends user auth cookie with request
    - Transaction will be fulfilled

- Problem:
  - browser is a confused deputy

GMail Incidence: Jan 2007

- Google docs has a script that run a callback function, passing it your contact list as an object. The script presumably checks a cookie to ensure you are logged into a Google account before handing over the list.
- Unfortunately, it doesn’t check what page is making the request. So, if you are logged in on window 1, window 2 (an evil site) can make the function call and get the contact list as an object. Since you are logged in somewhere, your cookie is valid and the request goes through.

Real World CSRF Vulnerabilities

- Gmail
- NY Times
- ING Direct (4th largest saving bank in US)
- YouTube
- Various DSL Routers
- Purdue WebMail
- PEFCU
- Purdue CS Portal
- …

Prevention

- Server side:
  - use cookie + hidden fields to authenticate
    - hidden fields values need to be unpredictable and user-specific
  - requires the body of the POST request to contain cookies
- User side:
  - logging off one site before using others
  - selective sending of authentication tokens with requests

Coming Attractions …

- More Web Security Issues
  - SQL injection
  - Side channel information leakage
  - Driveby downloads
  - Browser extension security
  - Cookie privacy issues