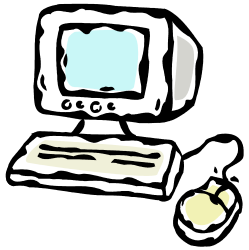
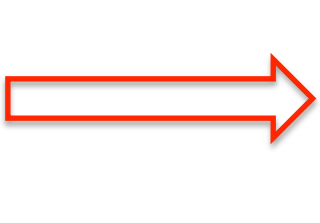
State management



```
GET /index.php HTTP/1.1
Host: www.mtech.edu
User-agent: Mozilla/4.0
```



```
HTTP/1.1 200 OK
Date: Thu, 17 Nov 2011 15:54:10 GMT
Server: Apache/2.2.16 (Debian)
Content-Length: 285
Set-Cookie: sessionID=528fa623; path=/;
Expires=Wed,  09 Mar 2014 11:00:00 GMT

<html><body>
<a href="mission.php">Mission statement</a>
<a href="press.php">Press releases</a>
…
```

```
GET /mission.php HTTP/1.1
Host: www.mtech.edu
User-agent: Mozilla/4.0
Cookie: sessionID=528fa623
```

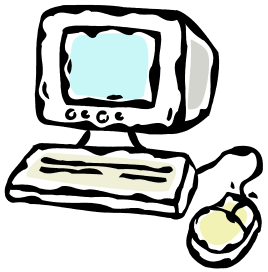
Overview

- The state management problem
  - For now, assume a single web server
- Possible solutions
  - IP address
  - Query string
  - Hidden form fields
  - Cookies
- State management in PHP

The state management problem

- HTTP protocol
  - A stateless, request/response protocol
  - No provisions for sessions that span multiple request/response cycles

```
GET /products.html HTTP/1.1
Host: www.mtech.edu
User-agent: Mozilla/4.0
```



```
HTTP/1.1 200 OK
Date: Thu, 17 Nov 2011 15:54:10 GMT
Server: Apache/2.2.16 (Debian)
Last-Modified: Wed, 14 Sep 2011
17:04:27 GMT
Content-Length: 285

<html> …
```

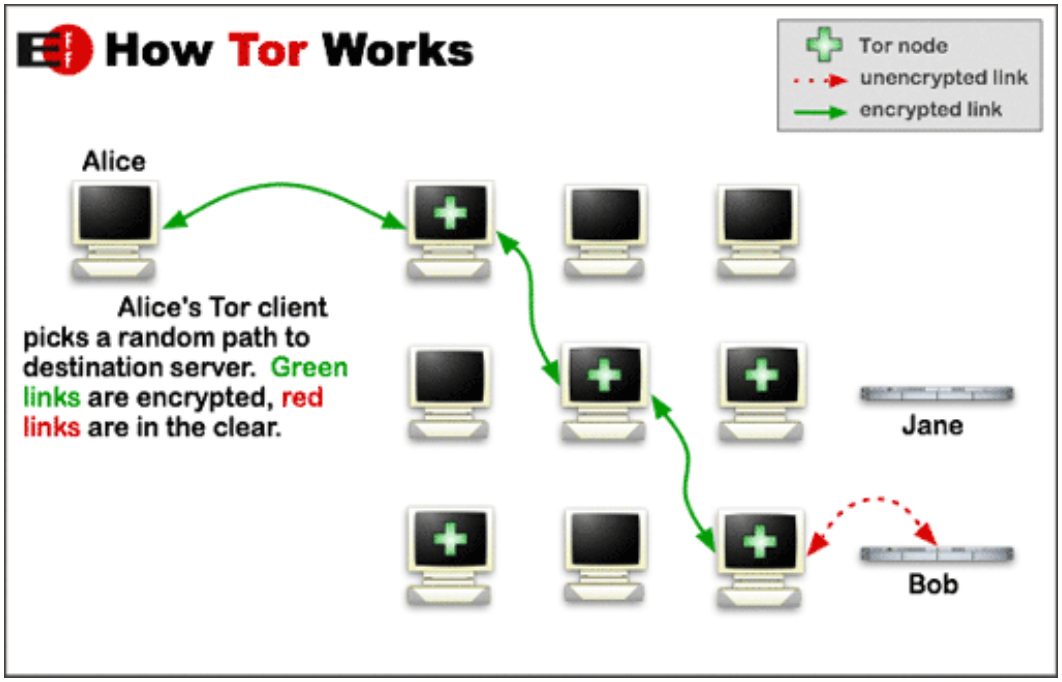
```
GET /checkout.html HTTP/1.1
Host: www.mtech.edu
User-agent: Mozilla/4.0
```

The goal of session-ness

- We want web apps to behave like desktop apps
  - Series of queries/responses
    - Made to appear as one ongoing user experience
      - e.g. User doesn't want to login on every page
- Problem 1: How to uniquely ID a session?
  - What exactly do we mean by "session"?
    - Person
    - Person + computer
    - Person + computer + browser
    - Person + computer + browser + browser tab
- Problem 2: Where to store the session data?
  - On the client, on the server, on the page?

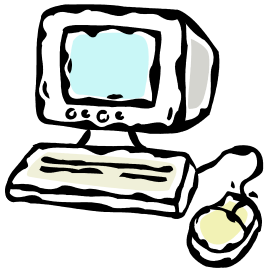
Identifying a session

- Option 1: IP address
  - Web server could use IP address of requestor
  - Not very reliable, broken by:
    - NAT - Different users on same net look like same user
    - Anonymity services such as Tor

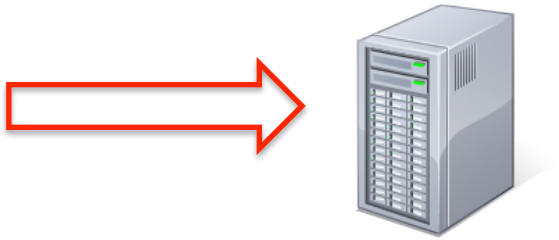


Identifying a session

- Option 2: Put something in the URLs
  - First hit to server, client uses plain URL
  - Server adds something to every returned link
    - e.g. http://myserver.com/index.php?id=528fa623



```
GET /index.html HTTP/1.1
Host: www.mtech.edu
User-agent: Mozilla/4.0
```



```
HTTP/1.1 200 OK
Date: Thu, 17 Nov 2011 15:54:10 GMT
Server: Apache/2.2.16 (Debian)
Content-Length: 285

<html><body>
<a href="mission.php?id=528fa623">Mission statement</a>
<a href="press.php?id=528fa623">Press releases</a>
…
```

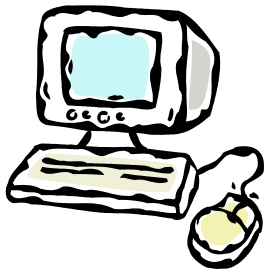
```
GET /mission.php?id=528fa623 HTTP/1.1
Host: www.mtech.edu
User-agent: Mozilla/4.0
```

Identifying a session

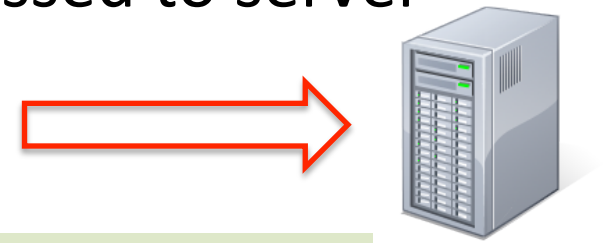
- Option 2: Put something in the URLs
  - Advantages:
    - Will work, can't be disabled
    - Supports independent sessions in different browser tabs
  - Disadvantages:
    - User can modify – change the session ID
    - User can bookmark – use later, no built-in expiration
    - Transient – session only as long as browser window
    - Leaks ID – in web server/firewall logs, other sites via HTTP REFERER field, to friends via emailing link

Identifying a session

- Option 3: Hidden form fields
  - First hit, add ID to hidden field in returned form
  - User submits form, hidden ID passed to server



```
GET /index.html HTTP/1.1
Host: www.mtech.edu
User-agent: Mozilla/4.0
```



```
HTTP/1.1 200 OK
Content-Length: 285

<html><body>
<form action="submit.php" method="POST">
<input type="text" name="username" value="" />
<input type="hidden" name="id" value="528fa623" />
…
```

```
POST /submit.php HTTP/1.1
Host: www.mtech.edu
User-agent: Mozilla/4.0
Content-Type: application/x-www-form-urlencoded

username=bob&id=528fa623
```

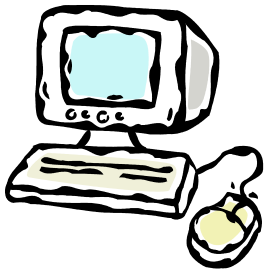
Identifying a session

- Option 3: Hidden form fields
  - Advantages:
    - Will work, can't be disabled
    - Information mostly hidden via POST
      - Not as obvious as embedding in URL string
      - Doesn't appear in bookmarks, log files, etc.
    - Supports independent sessions in different browser tabs
  - Disadvantages:
    - More complicated web pages
    - Everything has to become a form submission

Cookies

- Option 4: Browser Cookies
  - Introduced in Netscape, 1994
    - e-commerce app, needed to implement a shopping cart
  - Name/value pairs originally sent from server
  - Stored in browser (if cookies enabled)
    - User can delete
    - Expire after session or after elapsed time
  - When browser makes request to a particular site:
    - Sends any cookies marked for that domain
    - Server can use cookie to ID session
  - They cannot carry malware
  - They can have privacy implications

Anatomy of a cookie



```
GET /index.php HTTP/1.1
Host: www.mtech.edu
User-agent: Mozilla/4.0
```

```
HTTP/1.1 200 OK
Date: Thu, 17 Nov 2011 15:54:10 GMT
Server: Apache/2.2.16 (Debian)
Content-Length: 285
Set-Cookie: sessionID=528fa623; path=/;
Expires=Wed,  09 Mar 2014 11:00:00 GMT

<html><body>
<a href="mission.php">Mission statement</a>
<a href="press.php">Press releases</a>
…
```

```
GET /mission.php HTTP/1.1
Host: www.mtech.edu
User-agent: Mozilla/4.0
Cookie: sessionID=528fa623
```

Cookie attributes

- Domain
  - Defaults to domain of page that set cookie
  - Browser only sends cookie back to this domain
  - All hosts at a domain, leave off first part
    - For example: .mtech.edu
  - Cannot be different from page that sent cookie

```
HTTP/1.1 200 OK
Date: Thu, 17 Nov 2011 15:54:10 GMT
Server: Apache/2.2.16 (Debian)
Content-Length: 285
Set-Cookie: sessionID=528fa623; path=/; Expires=Wed,  09 Mar 2014
11:00:00 GMT

<html><body>
…
```

Cookie attributes

- Path
  - Defaults to path of page that set cookie
  - Browser only sends to pages below path:
    - e.g. if path is "/products/" only send to pages in products directory of web site

```
HTTP/1.1 200 OK
Date: Thu, 17 Nov 2011 15:54:10 GMT
Server: Apache/2.2.16 (Debian)
Content-Length: 285
Set-Cookie: sessionID=528fa623; path=/; Expires=Wed,  09 Mar 2014
11:00:00 GMT

<html><body>
…
```

Cookie attributes

- Expires
  - If not set, browser deletes when closed
  - Otherwise: specifies date and time of expiration
    - DOW, DD, MON, YYYY HH:MM:SS GMT
- Max-Age
  - Alternate to Expires, seconds in future

```
HTTP/1.1 200 OK
Date: Thu, 17 Nov 2011 15:54:10 GMT
Server: Apache/2.2.16 (Debian)
Content-Length: 285
Set-Cookie: sessionID=528fa623; path=/; Expires=Wed,  09 Mar 2014
11:00:00 GMT

<html><body>
…
```

Cookie attributes

- Secure
  - If present, browser only sends if on secure page
  - Server probably should only set on a secure page!
- HttpOnly
  - Use cookies via HTTP protocol only
    - Can't be accessed via JavaScript
    - Prevents cross-site scripting (XSS) attacks stealing cookies

```
HTTP/1.1 200 OK
Date: Thu, 17 Nov 2011 15:54:10 GMT
Server: Apache/2.2.16 (Debian)
Content-Length: 285
Set-Cookie: sessionID=528fa623; path=/; Expires=Wed,  09 Mar 2014
11:00:00 GMT; Secure; HttpOnly

<html><body>
```

XSS attack demo

```
<?php
if (isset($_GET['name']))
{
        $name = $_GET['name'];
        echo "Welcome $name<br>";
}
else
{
        echo "You didn't tell me your name!<br>";
}
?>
<br>
<a href="index.html">Home page</a>
```

name.php

name.php?name=Keith<script>alert('Hi there!')</script>

name.php?name=<script>window.onload = function() {var
link=document.getElementsByTagName("a");link[0].href="http://evil.com/";}</script>

index.php?name=%3c%73%63%72%69%70%74%3e%77%69%6e%64%6f%77%2e%6f%6e%6c%6f%61%64%20%3d
%20%66%75%6e%63%74%69%6f%6e%28%29%20%7b%76%61%72%20%6c%69%6e%6b%3d%64%6f%63%75%6d%65%6e
%74%2e%67%65%74%45%6c%65%6d%65%6e%74%73%42%79%54%61%67%4e%61%6d%65%28%22%61%22%29%3b%6c
%69%6e%6b%5b%30%5d%2e%68%72%65%66%3d%22%68%74%74%70%3a%2f%2f%61%74%74%61%63%6b%65%72%2d
%73%69%74%65%2e%63%6f%6d%2f%22%3b%7d%3c%2f%73%63%72%69%70%74%3e

http://www.thegeekstuff.com/2012/02/xss-attack-examples/

Third party cookies

- Cookies are sent only to server that set them
  - But: a site can link external images
    - e.g. banner ads
  - Most browsers default to allowing 3rd-party cookies

Storing session data

- Given session ID where to store other data?
- On the client:
  - In the URL string
  - In hidden form fields
  - In browser cookies
- On server, using session ID as key into:
  - Data in memory
  - Data on disk
  - Data in a database

Cookie-only state

- Complete state in client-side cookies
  - No server-side state, great for scalability!
  - Limited amount of data (browser dependent)
  - Only one session per browser
  - Cookies must be enabled in browser
  - Possibly risky, users can delete or change cookies

```
HTTP/1.1 200 OK
Date: Thu, 17 Nov 2011 15:54:10 GMT
Server: Apache/2.2.16 (Debian)
Content-Length: 285
Set-Cookie: products=343984,545454,98983;username=bob; path=/;
Expires=Wed,  09 Mar 2014 11:00:00 GMT

<html><body>
…
```

PHP sessions

- PHP session support
  - Provides a unique session ID
    - Done via cookies and/or URL fallback
  - Stores name/value pairs according to session ID
    - Defaults to using a temp file in /var/lib/php5
    - Works for a single server
    - Multiple servers requires a shared store:
      - Shared file system
      - Database (e.g. MySQL)
      - Shared memory cache (e.g. memcached)

Using PHP sessions

- Starting a PHP session
  - Assume for now cookies are enabled
  - Every PHP script runs `session_start()` function
    - You must do this before any other output on the page!
  - Sets a unique ID the first time
  - Returns the same ID every other time
  - ID is available using `session_id()` function

```
<?php
    session_start();
    echo "<p>Your session ID is " . session_id() . "</p>";
?>
```

Using PHP sessions

- Storing sessions variables
  - Make sure session is started at top of page
  - Use `$_SESSION` superglobal to get/set values

```
<?php
    session_start();
    $_SESSION["product1"] = "Snickers";
    $_SESSION["price1"]   = "1.25";
    echo "Product added.";
?>
```

First page that sets two session variables.

```
<?php
    session_start();
    echo "Product: " . $_SESSION["product1"] . "<br />";
    echo "Price: "   . $_SESSION["price1"]   . "<br />";
?>
```

Second page that shows what is currently stored in the session variables.

Using PHP sessions

- Check session variables before trying to use
  - Otherwise page will crash
    - Silently unless you've turned on PHP error reporting!
    - Set display_errors to On in /etc/php5/apache2/php.ini

```
<?php

    session_start();

    if (isset($_SESSION["product1"]) && isset($_SESSION["price1"]))
    {
        echo "Product: " . $_SESSION["product1"] . "<br />";
        echo "Price: "   . $_SESSION["price1"]   . "<br />";
    }
    else
    {
        echo "Your shopping cart is empty! <br />";
    }

?>
```

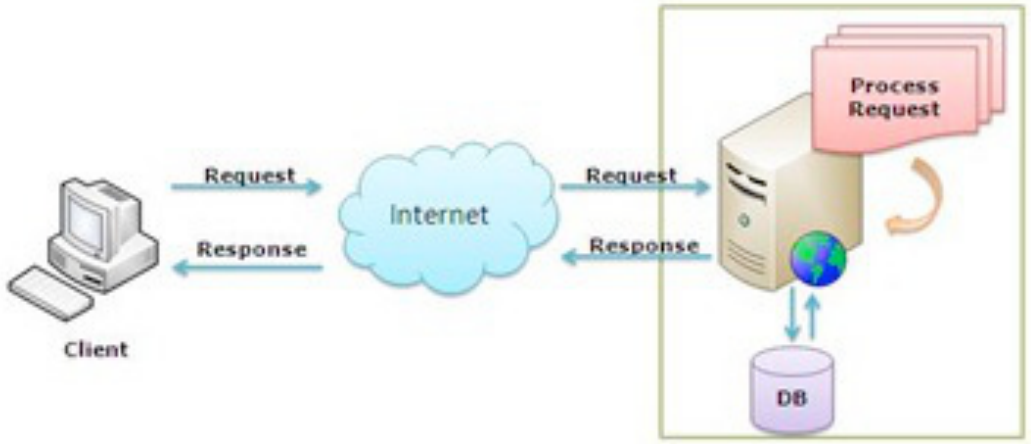
Using PHP sessions

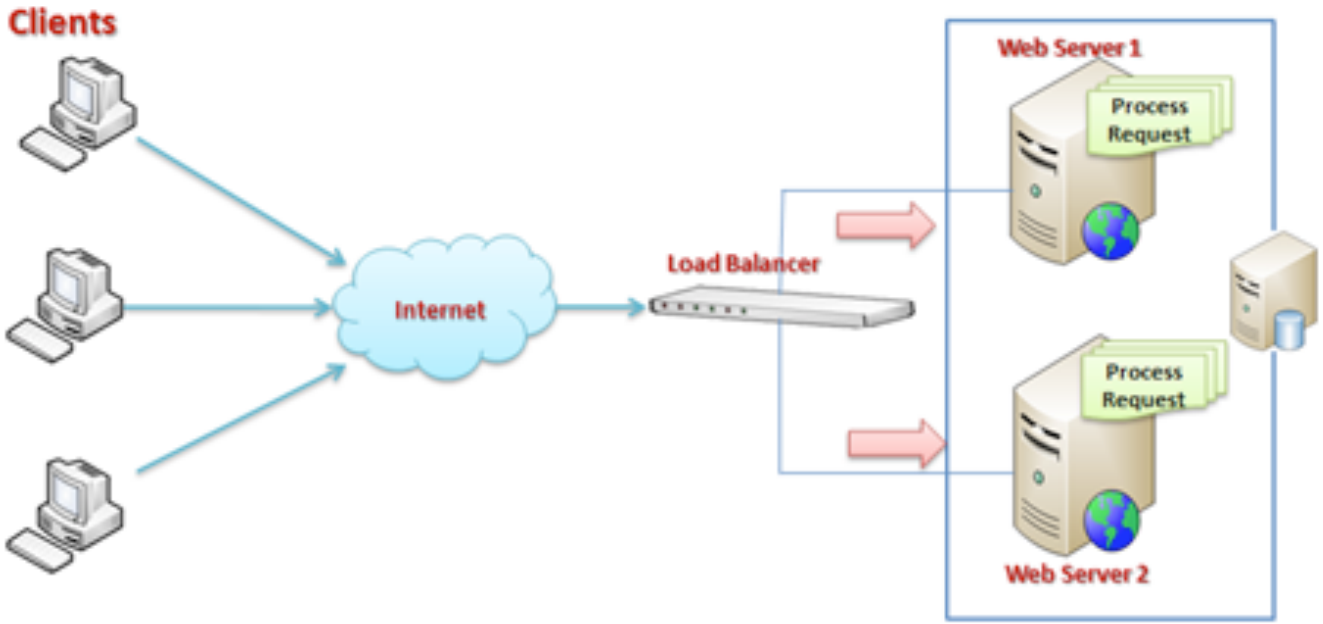
- What if cookies not enabled?
  - If cookie value not available, constant `SID` set
  - Append `SID` to GET parameters of all links on page
  - `session_start()` loads from GET instead of cookie
  - Session variables work as normal
  - BUT:
    - Turned off in PHP by default to guard against exploits

```
<a href="order.php?<?php echo SID; ?>">Order form</a>
```

```
<a href="order.php?PHPSESSID=738feaw23872">Order form</a>
```

Web farms





http://abhijitjana.net/2010/10/01/what-is-the-difference-between-web-farm-and-web-garden/

Summary

- Forcing state onto stateless HTTP protocol
- Find a way to unique track session
  - Using URLs
  - Using hidden form fields
  - Using cookies
- Store state somewhere
  - Client-side
  - Server-side