Part II: Explain how the Domain Name System works

Video: DNS

Refer to your downloadable resources for this video.

The Domain name system (DNS) protocol lets a user get the IP address of a computer at a particular domain name. When you type a domain name into the location bar of a web browser, your browser ask the DNS to translate the domain name to an IP address. The message sent to the DNS is made public, even if you are using HTTPS for a secure transaction. To protect user's privacy, a new protocol called DNSSEC has been developed, but it is not yet in wide use because it is slower. This tradeoff between security and speed is typical of the compromises that are made when creating protocols.

Many of the Internet's systems, including IP and DNS are hierarchical, meaning that they are organized in a tree. Hierarchical design is a strategy for making it likely that a working system will still work if it gets 1,000 times bigger. The Internet Corporation for Assigned Names and Numbers (ICANN), a nonprofit, non-governmental organization, controls domain names and IP numbers, and they give their authority to many other organizations one level lower in the hierarchy.

DNS servers are organized in a tree of delegated authority. The `root` points to several top-level domain servers like `.com` and `.org`. Each name server is responsible for knowing the IP numbers assigned to names in its domain, but it can delegate that responsibility to servers lower in the tree. All these servers are **authoritative DNS name servers**. They are the final authority on which IP numbers go with which domain names.
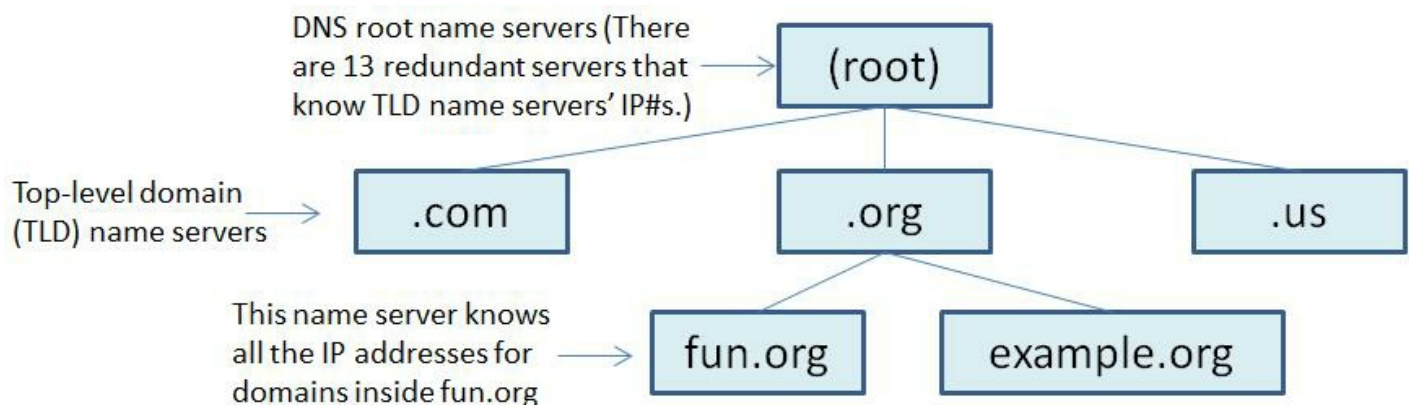
There is a computer with domain name `www.casos.cs.cmu.edu`. There is a name server you could ask to get the IP address for this computer.

7. What domain is this name server in charge of?
8. Name servers delegate autonomous authority to servers below them. For example, the `.org` name server doesn't keep track of IP addresses for all computers using domain names within `.org`.

    Why is this delegation of authority necessary?

    The DNS uses a second set of computers called recursive DNS name servers. These are the ones your computer actually talks to. The recursive name servers respond to your

requests by getting IP numbers from the authoritative name servers.

One example is diagrammed below. In this example, your computer wants to initiate a connection with the web server `www.example.org`, but it doesn't know the web server's IP address.

- Your computer will use TCP/IP to ask your recursive name server for the IP address of `www.example.org`.
- If your domain name server doesn't know, it will ask the root name server.
- The root name server will respond with the IP address of the `.org` name server(s).
- Then your recursive name server will ask the .org name server.
- The `.org` name server will respond with the IP address of the `example.org` name server.
- The `example.org` name server will respond with the IP address for `www.example.org`.
- Your recursive name server will finally respond to you and **cache** the answer in case the same question comes up again soon.

The information is cleared from cache when it expires in 1 to 3 days. This flurry of messages makes the system scalable. The messages are vulnerable to imposters, but making it less vulnerable with DNSSEC requires bigger messages and longer processing time.
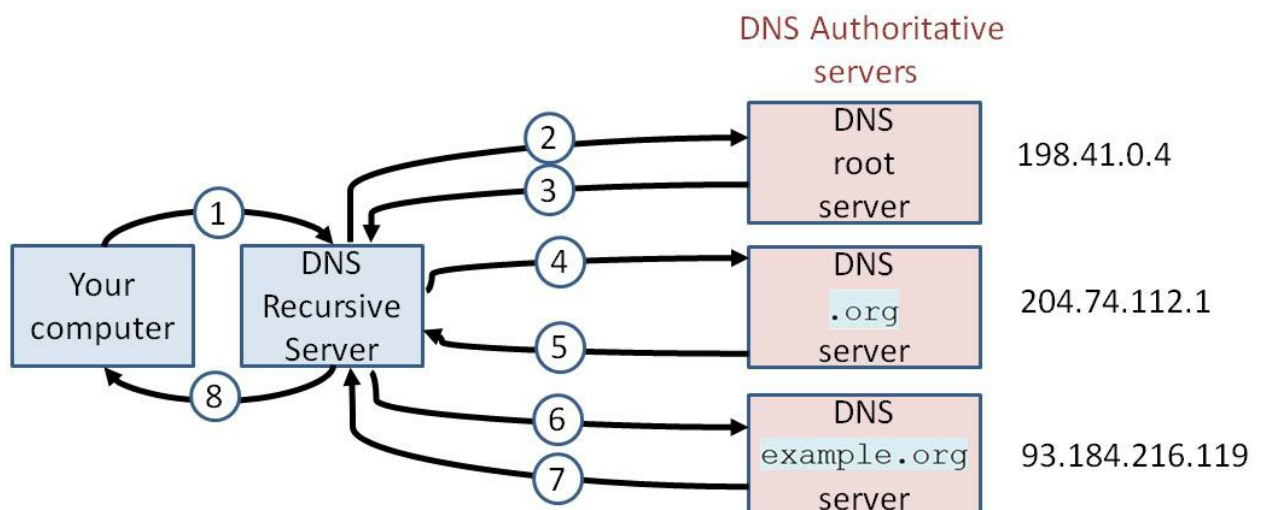
9. The six computers involved in the diagram are listed A–F. Record who says each of the messages 1–8 below, and to whom.
   - Your computer:
   - Your name server:
   - root name server:
   - `.org` name server:
   - `example.org` name server:
   - `www.example.org` web server:

   - from___to___: What is the IP address of www.example.org?
   - from___to___: What is the IP address of www.example.org?
   - from___to___: Ask 204.74.112.1

- from__to__: What is the IP address of www.example.org?
- from__to__: Ask 93.184.216.119
- from__to__: What is the IP address of www.example.org?
- from__to__: The IP# of www.example.org is 93.184.216.119
- from__to__: The IP# of www.example.org is 93.184.216.119

10. Record people's names to play parts A–F above. As directed by your teacher, act this out for the class, following the script as above.

Part III: Get situated on a server

11. If you have not yet created a workspace on Cloud9, do so now by following the instructions in the document *Lesson 2.1 Creating a Cloud9 Workspace*.

    Your Cloud9 workspace is a virtual machine. The terminal window provides a **command line interface (CLI)** to the machine's operating system. A command line interface:

    - Accepts a single command at a CLI prompt
    - Executes the command
    - Prints output resulting from the command

    This is a **read-execute-print loop (REPL)**. The IPython interactive session you have been using in Canopy is a REPL, too, so the idea should be familiar. The difference, however, is that the execution of your command is performed by the **operating system (OS)** instead of the *Python* **application**.

    The operating system controls the whole machine, including the input devices, processor, and output devices. An operating system is a program, and each application is a program. One machine runs one operating system, and the operating system can then run many applications. The operating system controls which applications send instructions to the processor and determines whether an application can have access to an input device, an output device, or a location in memory.

    A command line interface to the operating system is called a **shell**. Your Cloud9 machine is running the **Linux** operating system, with a particular Linux **distribution** (think of the OS as a brand and the distribution like a particular model) called Ubuntu. There are many applications for an operating system shell; Cloud9 uses the Bourne-again shell (**Bash**) application. Usually a remote user accesses a shell using the secure shell protocol (**SSH**), but Cloud9 provides the shell within a browser window by HTTP.

    The command line **prompt** shows that the REPL is ready for you to type a command. The shell prompt can be customized, and by default it shows your Cloud9 username and the **current working directory**. A **directory** is a folder in a **file system**; a file system is a collection of memory locations, most of which are directories (lists of other directories and files), data files, or application files. Most file systems are in the structure of a tree, in which each file or directory is the **child** of a **parent** directory, all the way up to the **root**. The `~/workspace` in your command prompt means that that the current working directory is `workspace`, a child of the directory `~`. That symbol `~` (a tilde, pronounced TILL-duh) is an abbreviation for your **home directory**, which is a directory belonging to a particular user on a

machine. Your Cloud9 user controls the entire virtual machine. The terminal, however, does not know that you are that special user; for now, you are just a specific user on the machine, with limited (but powerful) privileges. In the shell, for now, you are merely the user with username `ubuntu`.

You can determine your current working directory and username using the `pwd` and `whoami` commands.

12. At the CLI prompts, enter the commands shown below in red.

```
c9username:~/workspace $ whoami
ubuntu
c9username:~/workspace $ pwd
/home/ubuntu/workspace
```

The previous step introduced a lot of vocabulary!

13. Review the vocabulary in the Lesson 2.1 Key Terms and examine the commands in Section 1 of the Lesson 2.1 Reference Card.

One strategy to improve reading comprehension is to create a graphic organizer connecting the main ideas. Another strategy is to create a sentence describing the relationships that connect the main ideas. For example, write one or more sentences that describe how you use the command "pwd" and what it tells you, using the terms "operating system", "application", "shell", and "command line interface."

Part IV: Examine how the NIC gets you onto the Internet

In a later activity, you will publish a web page on the server. Our purpose now is to explore a computer's connection to the Internet. You will use several commands on a server to explore protocols used by the Internet:

- `ifconfig` and `ipconfig`   to check your own IP number
- `dig` and `nslookup`   to get an IP number for a domain name
- `ping`   to test latency
- `traceroute` and `tracepath`   to see routing of IP packets

A computer is connected to the Internet through a **network interface card (NIC)**. A NIC is set up using the program `ifconfig` (in a UNIX-like operating system) or `ipconfig` (in a Windows operating system). Your `ubuntu` user isn't permitted to reconfigure the NIC, but you can view information about the configuration and status of the NIC. A **System Administrator** might run this program as part of their job duties, which encompass a wide variety of responsibilities, including managing user accounts, configuring hardware, automating processes with scripts, backing up data, and maintaining a secure network.

14. From the Cloud9 Bash prompt, use `/sbin/ifconfig` to run the `ifconfig` program, located in the `/sbin` directory, as shown below.

```
c9username:~/workspace $ /sbin/ifconfig
eth0      Link encap:Ethernet   HWaddr 02:42:ac:11:1b:7b
```

```
        inet addr:172.17.27.123  Bcast:0.0.0.0  Mask:255.255.0.0
        inet6 addr: fe80::42:acff:fe11:1b7b/64 Scope:Link
```

You can use the mouse wheel to scroll through the lengthy output. There should be two NICs described: `eth0` is the machine's **Ethernet** card, and `lo` is a fictional device called the **loopback** device that lets a computer send packets to itself. An excerpt of the output is shown above.

15. Identify three pieces of information from the output.
    - Recall that data on the Internet is always sent in numbered packets, sent from one IP address to another IP address. Version 4 of the IP address protocol uses "dotted decimal" notation: four decimals between 0 and 255, separated by dots. The output shown above says that the Ethernet card has the IPv4 address `172.17.27.123`.

      What is the IP version 4 address of the NIC your Cloud9 machine?

    - Every network interface card has a Media Access Control address (**MAC address**, no special relationship to Macintosh computers) built into the card hardware when it is manufactured. Most NICs connect to the Internet by Ethernet over copper wires. Ethernet uses one or more shorter packets called frames to send each IP packet to the other devices connected to the copper wires, and the frames include the sender's MAC address and the target recipient's MAC address. Each MAC address has six 2-digit hexadecimal numbers separated by colons. The MAC address shown in the output above is `02:42:ac:11:1b:7b`.

      What is the MAC address of the NIC on your Cloud9 machine?

    - There were only 256 * 256 * 256 * 256 addresses possible with IP version 4. (Can you explain why?) In 2012, the Internet ran out of addresses. For that reason, gradually, Internet traffic is shifting to IP version 6, and most NICs can use either version. IPv6 addresses are written in colon-hexadecimal notation: eight 4-digit hexadecimal numbers separated with colons. Leading zeros are left out, so a number like 0c4f is written as c4f. If one or more of the 4-digit numbers is zero, the 0 or 0's are replaced with a double colon. The output above shows that the Ethernet NIC has IPv6 address `fe80::42:acff:fe11:1b7b`, which is shorthand for `fe80:0000:0000:0042:acff:fe11:1b7b`.

      What is the IPv6 address of the NIC on your Cloud9 machine?

Part V: Use the domain name system to look up IP addresses

Your web browser normally talks to the Domain Name System (DNS) without you even knowing about it, but you can access the system directly. On Windows and UNIX-like machines, the `nslookup` command will ask your recursive name server to get the IP address assigned to a domain name.

16. Look up `www.pltw.org` as shown below.

```
c9username:~/workspace $ nslookup www.pltw.org
Server:         172.17.0.1
Address:        172.17.0.1#53

Non-authoritative answer:
Name:   www.pltw.org
Address: 190.93.242.249
Name:   www.pltw.org
Address: 190.93.241.249
```

Note that the results indicate a non-authoritative answer. This means that the information was from the cache of the recursive name server 172.17.0.1, rather than freshly obtained from the name server for `.org.` or `pltw.org`. The DNS reported two IP addresses for the domain name `www.pltw.org`, so web requests can be sent to either IP address. Redundancies, like having two machines ready to respond to a web request, make a system **resilient** and **robust**, two words used to describe software and systems that are resistant to failure.

17. Use `nslookup` to find the IP address for the web server of your favorite web page. Simply type `nslookup` followed by the domain name of your favorite website.

    ```
    c9username:~/workspace $ nslookup www.coolsite.com
    ```

    Record your information here. URL of favorite website:
    _____

    IP address of favorite web server:_____

18. To see the work of the authoritative DNS servers, use the `dig` (domain information groper) program with the `+trace` option as shown below.

    ```
    c9username:~/workspace $ dig www.example.org +trace

           (...lots of output and finally the output:)

    www.example.org.  4697   IN   A    93.184.216.119
    ```

    There is much more output from the dig program than shown here. First, the recursive DNS server reports the domain name of one or more root servers. The recursive server asks one of the root servers for the IP address of `www.example.org`. That root DNS server responds with the domain names (and IP addresses, though not shown in the output) for the `.org` name servers. The `NS` records refer to other name servers, while the `A` record shown above finally gives the address.

    How many separate machines are serving DNS for the top-level `.org` domain?

Part VI: Measure latency and bandwidth

The `ping` command is another commonly used tool to see behind the curtain in a computer network, on both Windows and UNIX-like systems. The command uses a simple protocol: one host sends a packet asking for an echo, and the target host responds. The ping command repeats the

process for many iterations. It reports how long the round trips took and whether any packets were dropped. Use Ctrl-c to **kill** the `ping` **process**. A process is a program or distinct thread of a program. Killing a process tells the operating system to stop executing it.

19. Execute the command with your own choice of domain name in place of `www.example.org`. The last line of output is shown below.

```
c9username:~/workspace $ ping www.example.org
rtt min/avg/max/mdev = 17.385/17.439/17.585/0.108 ms
```

This output shows that the packets traveled round trip from `pltwcs.org` to `www.example.org` in 17.439 ms, on average. A signal can travel one million feet of copper wire in 1 ms!

Try a few domains; what is the fastest response you can find?

Ping tells you about the **latency** between two computers' devices. Latency is the delay in a connection. Latency is different than **bandwidth**, which is the rate at which data can be pushed into or out of a device or through a connection. Bandwidth is limited by the narrowest "pipe" along the way: the processor, the network card, cables, switching hubs, etc. Bandwidth and latency can be observed through a browser.

20. In a new tab, navigate to `http://www.speedtest.net`.
21. After the page loads, select a target location on the detailed map to start the test. Sample results are shown below.

22. Record the target location you selected, along with your results. Include units.

Target location: _____   Ping: _____

Download speed: _____   Upload speed: _____

In step 21, the example download speed is 5.28 million bits per second. Below is work calculating how long it would take to retrieve a 3 GB file at that speed.

3 GB = 3 billion bytes = 24 billion bits

$$24 \text{ billion bits} = \frac{1 \text{ second}}{5.28 \text{ million bits}} = 4545 \text{ seconds}$$

23. Given the download speed you measured, calculate how long it would take to download a 450 kb file. Show your work.

Part VII: Observe that IP packets travel multiple paths

Every packet sent through the Internet is passed from one computer to the next until it arrives at its

destination. The `tracepath` utility asks computers along the way to report back to the sender. The sender can then see the route packets are taking.

Track the route of packets from the Cloud9 server back to the computer in front of you as follows.

24. Use `whatsmyip.org` in a new browser tab to identify the IP address of your computer. (This might be your school's router's IP address. ipconfig would find your computer's IP address, but it might be only internal to the school network. We'll ignore these complications.)

    Record the IP address from the top of the page.

25. To find the paths from the Cloud9 server to the computer that you are using, you need the tracepath utility.

    First, install tracepath on the Cloud9 machine using the following command.

    ```
    c9username:~/workspace $ sudo apt-get install iputils-tracepath
    ```

    The `sudo` command lets you execute any other command as the "superuser" with unlimited rights. The `apt-get` program is the advanced packaging tool, and it takes two arguments: a command like `install` and a package like `iputils-tracepath`.

    You should see lots of output.

26. Now, execute the `tracepath` command on the server, followed by your computer's IP address. Ctrl-c will stop the tracepath program early if desired. Use your IP address instead of `63.152.11.159` as in the example below.

    Packets contain the maximum number of hops that can be sent, known as the time-to-live (TTL). When an Internet host forwards a packet, it **decrements** the TTL. If the TTL reaches 0, the packet is dropped and an error message is sent back to the sender's IP. The tracepath program sends IP packets that will survive only one hop, two hops, or three hops, and so on, so it can receive error messages from the machines along the way to the destination, revealing their IP addresses. Some machines won't send back an error message if they get a packet that has run out of hops, resulting in "no reply".

    How many hops does it take to reach you? As an example, one line of output is shown below, indicating that a packet sent to 63.152.11.159 that was set to expire after five hops had reacher of hop #5 is shown below.

    ```
    c9username:~/workspace $ tracepath 63.152.11.159
    mi
    rtt
    5:  PR01.LAX03.google.com (206.223.123.21) 17.827ms
    ```

27. In a new browser tab, use the service at `iplocation.net` to determine the geographical location of the IP addresses through which the packets hopped. Sketch the path on the map below, labeling locations along the way. Note that location data may be missing or conflicting. Map the locations that seem to agree with other data.

Part VIII: Infrastructure and Organizations

Ethernet has been a critical technology in the development of computer networks. Originally developed by Xerox PARC in the 1970s, Ethernet is a protocol for sending bits over cables. A sequence of Ethernet bits is called a frame, and an IP packet can be split across several frames. The cables are usually copper wires twisted in pairs, with bits represented as voltage. The twisted pairs of wires in one cable can carry up to 100 megabits per second.

A newer technology has glass fibers that use light to represent the bits. Known as Gigabit Ethernet, the Ethernet standard for glass fiber can carry 1000 megabits per second. Bringing glass fiber-optics directly to the home is a new service, with vendors competing to connect entire cities.

28. How much faster is Gigabit Ethernet than the bandwidth you observed in Step 21 using speedtest.net?

29. Create one group with the entire classroom and repeat the procedure above. What changes?

What, if any, do the limitations of this protocol seem to be?

TCP, IP, and Ethernet were developed by researchers at Xerox PARC with U.S. military funding. Now the **Internet Engineering Task Force (IETF)** is responsible for maintaining the TCP/IP suite of protocols. In 2013, the IETF began a discussion that may lead to a more secure Internet. Some protocols are being considered to help protect the online activities of citizens from being monitored. This initiative was sparked when Edward Snowden leaked classified documentation about National Security Administration (NSA) efforts to monitor U.S. citizens. The Department of Defense, the NSA, Xerox PARC, and IETF are examples of

entities that have influenced the development of computing and the Internet.

30. Use the Internet to find a web page or article about international issues regarding the Internet and governmental programs for monitoring civilian communication.
31. Skim the article to determine what it is about.
32. Summarize what you learned from the article.
33. For each of the following listed entities, use the Internet to determine their responsibilities to the Internet:

    ○ IETF

    ○ W3C

    ○ ICANN

Refer to your downloadable resources for this material. Interactive content may not be available in the PDF edition of this course.

Conclusion Questions

Web pages are transmitted in packets using the HTTP protocol. DNS protocols are used by your machine and its domain name server to obtain the IP address of the web server when you request a web page. TCP is a protocol for breaking the information into packets and for reassembling packets into segments.

1. Match each protocol on the left with its purpose on the right.

○ IP	1. How to request Web content
○ TCP	2. How to address and route packets
○ DNS	3. How to sequence packets and verify accuracy
○ HTTP	4. How to get the IP address for `retailer.com`

2. Why are protocols necessary?
3. Why do protocols get outdated?
4. How do governmental agencies, corporations, and non-governmental organizations affect the development and functioning of the Internet?

HTML and CSS

Introduction

You've learned that data gets transferred from one machine to another by following protocols. But what is the data? Why do web pages look different on different computers? What is a web page, really?

The World Wide Web Consortium, W3C, is an organization dedicated to producing standards dictating the answers to many of these questions.

Materials

- Computer with web browser
- Cloud9 credentials and workspace

Resources

2.1.4 sourceFiles.zip

2.1 Reference Card UNIX-HTML-CSS.docx

Procedure

It is easy to create simple websites with a WYSIWYG editor, like Adobe DreamWeaver, for example, without having to write code. WYSIWYG stands for "What You See Is What You Get." Most professional web developers, however, need to work more directly with the underlying code to achieve the exact features that clients want. Today you will learn what is happening behind the scenes when web pages are created and accessed. The web pages you create will be simple; we are not aiming for elegant. However, the *way* the web pages *work* will be exposed to you so you can see what the code does. If you wish to develop more elegant websites using a web design application, your knowledge of HTML and CSS code will give you much more power to customize your site and fix problems.

Part I: Publish a Web Page

1. Meet or greet your partner for this activity and establish team norms.

   For this activity, you will try another method of collaboration than pair programming. You will be working in a shared workspace that permits four-hands programming. Like pair programming, the partners will work together to produce a single artifact. Unlike pair programming, in the collaboration method for this activity, both partners can use their own

keyboard and mouse to interact with a shared environment. You should still take advantage of being seated together by sketching on paper, gesturing to code on each other's screens, and making eye contact during conversation, but you can use this virtual space to work together as well.

Each workspace is owned by exactly one Cloud9 user, but that user can share the workspace with other users.

2. Log in to Cloud9 at **https://c9.io**. Each partner should do this.
3. From your dashboard, open the workspace you created in the last activity. Recall that each workspace is its own virtual machine with the Linux operating system. Each partner should do this.

Each person can develop their own website, in their own workspace. However, the partnership can also develop a single workspace together in a shared environment that gives both partners access. Even if you intend to complete the assignment using two separate workspaces, begin the activity using a single shared workspace, so that you can experience this unique Google-doc-like environment for coding. Pick one person who will technically "own" the workspace that you share.

4. Share the owner's workspace with the other user as follows.
    o In the upper right of the workspace window, select **Share**.
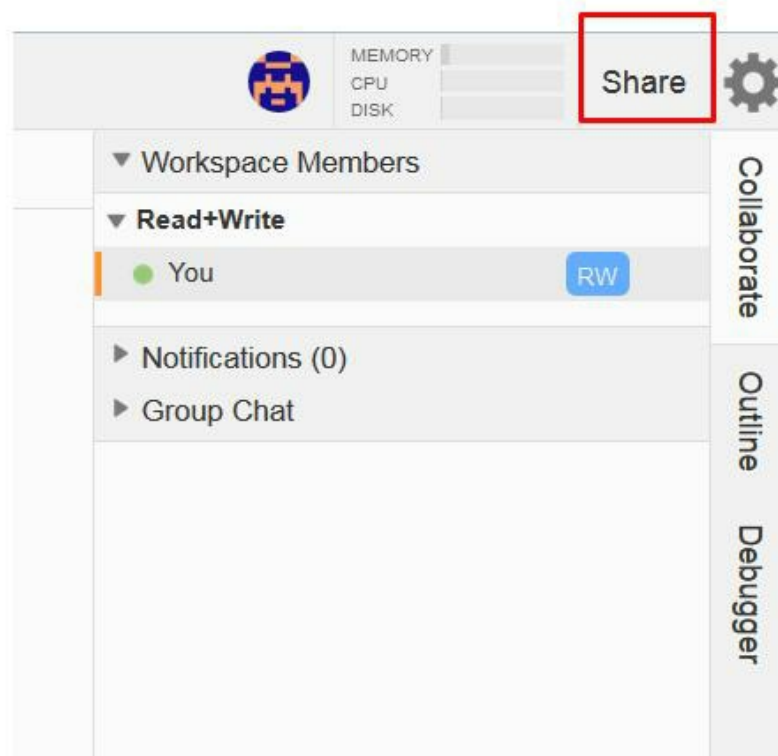
    o Type the Cloud9 username to share the project.
    o A sharing invitation can have permissions to read (R) or to read and write (RW). Leave the permissions on the default RW (


) and select **Invite**.

The Cloud9 environment can also be a useful tool for your teacher; the teacher can circulate among students' workspaces using different tabs in their own browser.

- If directed by your teacher, enter your teacher's Cloud9 username and select **Invite**.
- To access a workspace that has been shared with you, go to your dashboard. If you have already entered one of your workspaces, you can access the dashboard by selecting **Cloud9** > **Go to Your Dashboard**. The dashboard will open in another browser tab.
- Select **Shared With Me** from the left-hand navigation bar on the dashboard. Open the workspace that your partner has shared with you. It can take a minute or two for a workspace to appear after it has been shared with you, but you can proceed with these instructions while waiting.

You will create a document containing Hypertext Markup Language (HTML) for a simple web page. HTML is the basic language for web content. You can avoid publishing content if you prefer. To keep content unpublished, do not start the Apache server on Cloud9.

5. Create a new document as follows.
   - Select the circled plus sign to the right of a Cloud9 tab and select **New File**.
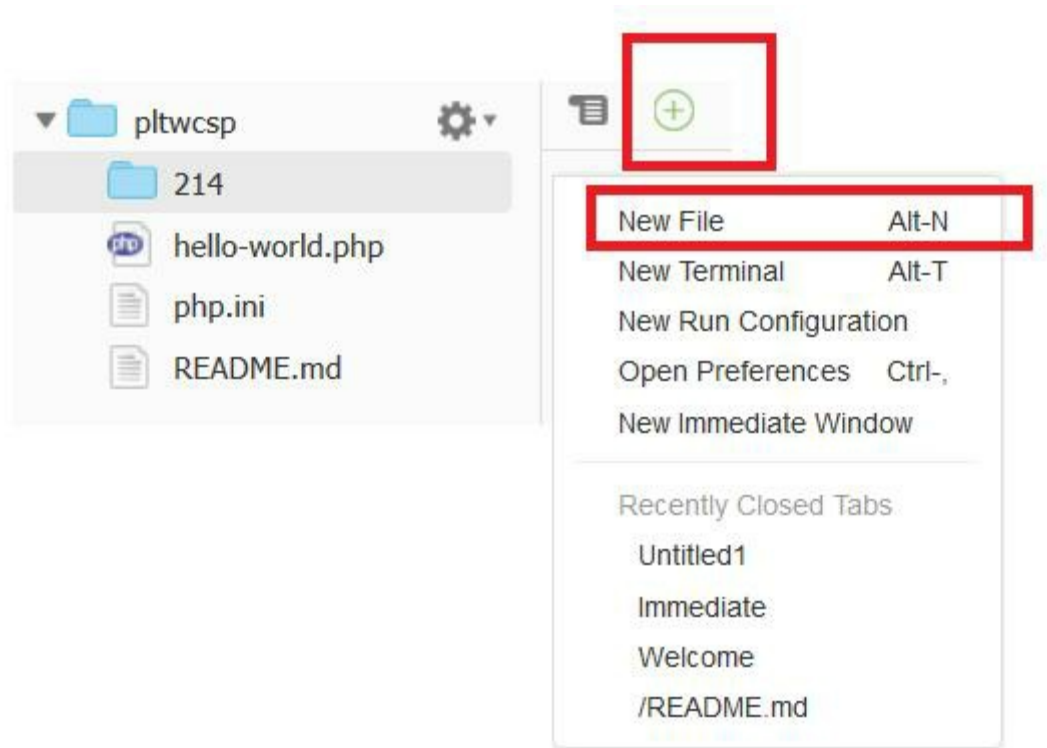
- Type or paste the following text into the editor.

```html
<!doctype html>
<html lang="en">
    <head>
        <meta charset="utf-8">
        <title>Jane Jones' Website</title>
    </head>
    <body>
        <h1>
            This is easy and fun!
        </h1>
    </body>
</html>
```

Unlike the *Python* interpreter reading a *Python* file, a browser reading an HTML file does not care much about white space (new lines, tabs, spaces). The indentation shown in the HTML above makes it easier for a human to see how the code is structured, but the indentation does not affect the rendering by a browser.

Web servers are usually configured to serve the file named `index.html`, if no other name is specified by the client.

- Save the file in your `214` folder with the name `index.html`.

Congratulations! You're published! Anyone in the world can now see your work. Your teacher will provide guidelines about what NOT to publish. Summarize them here.

6. Professional web developers do not develop on a live site. They work on a private site and publish once work is complete.

   To view an unpublished client-side web page (i.e., HTML, CSS, JavaScript, and audiovisual media) as though it had been published, you have two options:

   - Save the file(s) on your local machine and then open the HTML file in a browser. These files can be edited with Notepad++ or another **text editor**, which allows you to edit text characters without adding rich formatting data.
   - Upload to or create the file(s) in Cloud9 and use the preview feature without running the Apache web server. The Cloud9 preview feature **emulates**, or mimics, a wide range of browsers. To view the rendered file, select the file in the Cloud9 environment, select **Preview**, and then select the desktop or mobile browser to be emulated.

   In the next lesson, you will learn to create web pages that include **server-side features** in which code executes on the server. To get comfortable with Cloud9 and Apache, this lesson recommends that you publish content on Cloud9 and view rendered files by loading or refreshing a browser's request to the web server.

Part II: Content and Style

The code that you provide in an HTML document specifies what content will be displayed by the web browser. It contains text and possibly references to external files like images or music.

7. The tags you may use in HTML provide limited stylistic functionality. Copy the following HTML into a new Cloud9 file and save the file as `ice.html`.

```
<!DOCTYPE html>
 <html>
   <head>
     <meta charset="utf-8">
     <title>I Scream For Ice Cream!</title>
   </head>
   <body>
     <h1>Most Popular Ice Cream Flavors</h1>
     <table>
      <tr><th>Rank</th><th>Flavor</th></tr>
      <tr><td>1</td><td>Vanilla</td></tr>
      <tr><td>2</td><td>Strawberry</td></tr>
      <tr><td>3</td><td>Chocolate</td></tr>
      <tr><td>4</td><td>Cookies and Cream</td></tr>
      <tr><td>5</td><td>Mint Chocolate Chip</td></tr>
     </table>
   </body>
 </html>
```

8. Use what you observe when you view that file as a web page online along with the resource *Lesson 2.1 Reference Card UNIX-HTML-CSS* to explain what each of the following
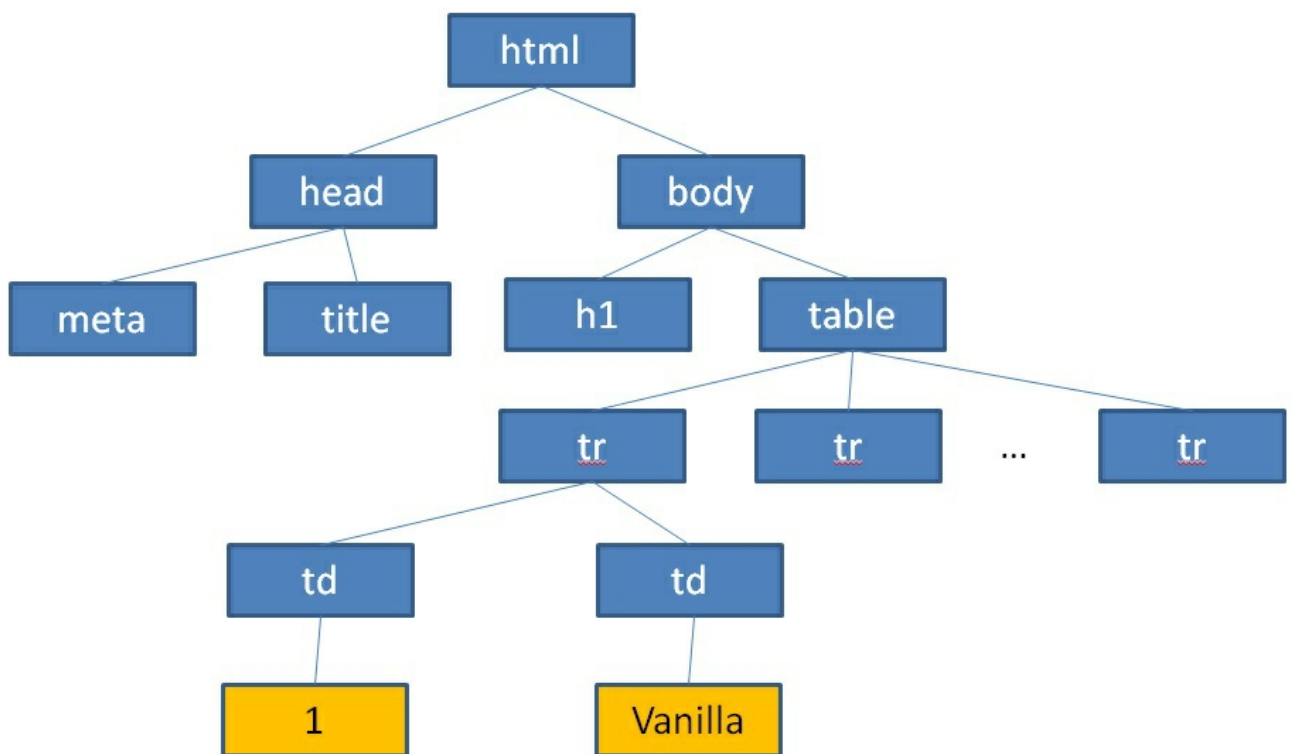
tags do:

`<h1>`	
`<table>`	
`<tr>`	
`<td>`	

The structure of a web page can be viewed as a tree. The root node is the `<html>` tag, which has two children: the `<head>` tag and the `<body>` tag. The `<head>` tag generally contains information about the page, whereas the `<body>` tag contains content.

In the tree diagram shown below, is "Vanilla" part of the `<head>` or part of the `<body>`?

9. Add an image to your page as follows.
    o Find an image of cookies online and save it as `cookies.jpg`.
    o Upload it to your Cloud9 workspace by selecting **File > Upload Local Files** or by dragging an icon of the file and dropping it onto the Cloud9 file tree viewer.

    Most web servers allow you to upload files using the File Transfer protocol (FTP). What you accomplished in this step using HTTP is equivalent to what is usually accomplished with FTP. Name another real-life example in which two different protocols for computer

or human behavior can accomplish similar effects.

- You can display the cookie picture on your web page by adding this line of code within the `<body>` **element**. An element is one object with the document, usually started and ended by an HTML tag.

  ```
  <img src="cookies.jpg" />
  ```

- Save the modified HTML and refresh the view in the browser. You should see your page with an image of cookies.

A good website has well organized files. Understanding the directory structure of the web server will allow you to create a site with well-organized files.

10. In the Cloud9 workspace, create a directory named `images` within your `214` folder.
11. Drag or otherwise move the cookies.jpg file into the images folder.

    What happens when you reload your web page in the browser?

12. The `img` tag has an `alt` attribute that will display text if the image cannot be loaded or displayed. That `alt` text can be spoken by a screen reader for a web user with a vision impairment.
    - Modify your `img` tag from the previous step to look like this: `<img src="cookies.jpg" alt="Picture of Cookies" />`.
    - Save the new HTML and refresh the browser tab in which you were rendering the page.
    - What changes?

    You have a broken link on your page because the cookies image isn't in the location that the HTML has recorded.

13. You can fix this by specifying the path to that image resource. There are two methods to specify a path.
    - A **relative path** tells the browser to ask for a location starting with the path of the file currently being rendered. Because "images" is a folder within the directory containing `ice.html`, you could refer to the image using `<img src="images/cookies.jpg" alt="Picture of Cookies" />`, where `src` assumes the current document's directory as the place to find the folder `images`.
    - An **absolute path** to a resource starts from the root of the web server and includes the domain name. You can refer to the image as `<img src="https://workspacename-c9username.c9users.io/214/images/cookies.jpg" alt="Picture of Cookies" />`. You will need to use your own Cloud9 workspace name and Cloud9 username in the domain name.

14. Decide with your partner whether to use absolute or relative references to load your image. Explain what you think the advantages might be for each approach.
15. Try the solution of your choice by modifying the HTML, saving, and refreshing the rendered page in your browser.
16. Create a new file in your Cloud9 workspace called `icecream.css`. Copy the following Cascading Style Sheet (CSS) code, paste it into your file, and save the file. Style sheets let you apply a variety of visual effects, such as font, boldness, center alignment, or background color to your web page. The standards and specifications for using CSS are maintained by

W3C ®, the World Wide Web Consortium.

```
body{
    font-family: "Marker Felt", "Comic Sans MS", fantasy;
     color: #003366;
 }

 h1  {
         font-size: 1.3em;
         text-align: center;
 }

 table {
         margin-left: auto;
         margin-right: auto;
         text-align: left;
         border-collapse: collapse;
 }

 tr    {
         border: 1px solid #ffffff;
         text-align: center;
         background-color:#9FB6CD;
 }

 th    {
         text-align: center;
         color: #ffffff;
         background-color: #003366;
 }
```

An **external style sheet** is a file that exists independently of your HTML document and contains only style information. For this external style sheet to influence the appearance of your website, you will need to reference it within the `<head>` tag of your HTML document. This type of styling is referred to as a linked style sheet.

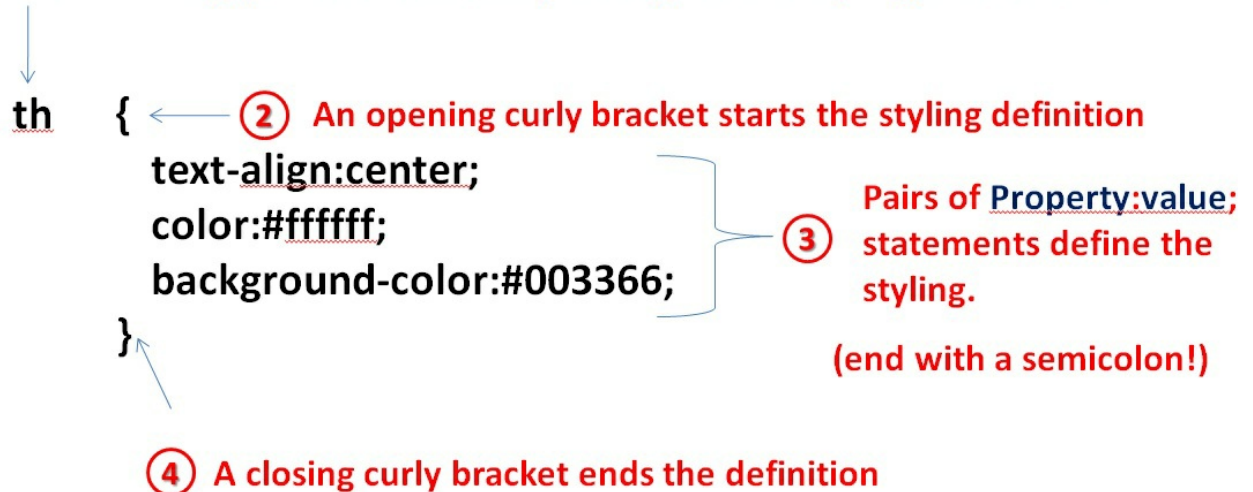17. Paste the following code into your `ice.html` file within the `<head>` element and save that file.

```
<link href="icecream.css" rel="stylesheet" type="text/css">
```

18. Save both the `ice.html` and `icecream.css` files and reload the `ice.html` page in your browser.
What changes in appearance do you notice?

The following is a diagram of the syntax of a single style definition in CSS. The source code appears on lines 25–29 of `icecream.css` shown above.

① **The HTML tag (called the *Selector*) is assigned the styling that follows.**

```
th    {
        text-align:center;
        color:#ffffff;
        background-color:#003366;
      }
```

② **An opening curly bracket starts the styling definition**

③ **Pairs of Property:value; statements define the styling.**

(end with a semicolon!)

④ **A closing curly bracket ends the definition**

The <u>selector</u> tells CSS which part of the HTML should be stylized. There are several different properties of any given selector, which you can use CSS to modify. This particular definition modifies the text alignment, color, and background color of cells within a table. A value must be specified for each property.

What does line 8 in step 16 tell us about how `<h1>` tags will appear on this web page?

Linked style sheets are a good way to set up rules for how different parts of your entire web page will look. There are two other ways of incorporating CSS that allow you to set up rules for specific parts of your page. The "cascading" part of Cascading Style Sheets refers to more general definitions being overridden by definitions that are more specific to the context that you're focusing on. The external style sheet may be referenced by dozens or even hundreds of pages. You can use an <u>internal style sheet</u> within the `<head>` element of your page to specify styles just for this document.

19. Paste the following into your `ice.html` file within the `<head>` element.

```
<style>
  td {color: #FF0000;}
</style>
```

Save the changes and refresh your view of the page in your browser. What has changed?

Internal style sheets give you the power to control the contents of a single document. You can set up a rule for an even more specific part of a document using an <u>inline style</u>. Inline styles are contained entirely within a single tag.

20. Choose one `<td>` tag in your `ice.html` file to change from this: `<td>` to this: `<td style="color:#00FF00; background-color:sienna;">`.
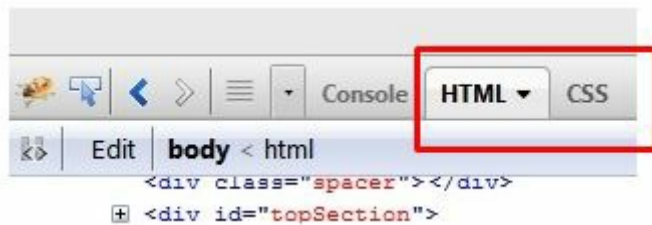
What changes when you save the file and refresh the rendered tab in the browser?

We will use Firebug to help you understand which HTML and CSS components cause

different parts of a page to be rendered differently. We'll use your ice cream page.

21. Follow these steps and then answer the questions below.
    - View your ice cream page in Firefox by typing the address in the location bar. Turn on Firebug.
    - Switch back and forth between the HTML and CSS tabs to answer the questions that follow.

    - You can mouse over a line of code in Firebug and it will highlight the visual region within the browser window that particular HTML code is affecting.

      Mousing over CSS code will show you a visual representation of the property that is being impacted when, if the element is visible.

      Mouse over some CSS to answer the following questions.

    - What line of code in the HTML links to the external style sheet so that sections 1, 2, and 3 have more visual appeal than they would if this were created using plain HTML?
    - Which property in the CSS file dictates the background color of the cells in the row containing "Rank" and "Flavor"?
    - What line of HTML code creates the row of cells in section 3?
    - What is the tag responsible for making the text in section 1 appear larger than the text in the other sections?

Part III: Navigate around the server with Linux commands

Your web page is being served from a machine running the Linux operating system, which is similar to all the other operating systems in the UNIX® family. Knowing a handful of UNIX commands can be *very* handy, since the majority of processing power runs under UNIX-family operating systems. The purpose of this part of the activity is to show you how to move around on a UNIX server.

22. At the Bash command line, type `pwd`, which stands for "print working directory." It shows you the path through the directory structure to your current location.

    Record the output here.

23. Enter the command to list information about files: `ls`.
24. Compare the output to the file browser that is on the left side of the Cloud9 workspace.

    The Cloud9 file browser only shows files within a specific directory on the Cloud9 machine: the directory you identified in the previous step. The Cloud9 file browser uses icons to indicate whether an item in a directory is another directory, an executable file, or a text file.

    How does the ls command indicate the file type?

    Linux commands often offer options to provide additional functionality. You can quickly learn about the options available to various Linux commands using the `man` feature, short for "manual". Linux uses **flags** to provide this additional functionality. When you type a command, you follow it with a space, a hyphen, and then a letter or sequence of letters. One particularly useful set of options for the `ls` command is the `-la` flag combination. The whole command would be entered like this: `ls -la`.

25. Type `man ls` at the command line to bring up the manual pages for `ls`.

    The manual is too long to fit on one screen, so the Linux operating system **paginates** it. You can use `Ctrl+f` to move a page forward or `Ctrl+b` to move a page backward.

26. Read the manual page to find out what the `-l` and `-a` flags do. Record your findings below.

`-l`	
`-a`	

27. When you are done, press the q key to quit the paginator.

    Now try using both the `l` and `a` flags. When you enter `ls -la`, you should see output similar to that shown below in your terminal.

```
mepi:~/workspace (master) $ ls -la
total 48
drwxr-xr-x   8 ubuntu ubuntu 4096 May 11 07:38 ./
drwxr-xr-x  19 ubuntu ubuntu 4096 May 11 07:43 ../
drwxr-xr-x   3 ubuntu ubuntu 4096 May 11 04:09 .c9/
drwxr-xr-x   2 ubuntu ubuntu 4096 May 11 04:08 223/
-rw-r--r--   1 ubuntu ubuntu   65 May 11 04:08 README.md
-rwx--x--x   1 ubuntu ubuntu 1650 May 11 07:50 initialize.sh*
```

| Permissions | Owner | File Size | Last Modified | File Name |

What user is the owner of the files in your home directory?

The first two directories listed in your home directory should be ./ and ../. The single dot always refers to the current directory, and the double dot always refers to the parent of the current working directory. The parent is the directory one level above your working directory in the file structure. You will use the cd command to navigate the directory structure. The command cd stands for "change directory" and must be followed by the name of a directory accessible from the current working directory or the full path to another directory such as /home/.

28. To navigate to the parent of your current directory, type cd ...

    What command can you use to display the path for the directory you are currently in? Record that path here:

29. Use the appropriate command to list the contents of your current directory.

    What do you think the file names represent?

30. Spend a moment exploring the directory structure using the commands that you have learned. Then navigate to /home/ads/.

    Each user has a directory here. Write down the name of one account's directory other than your own or that of your teacher.

    Learn how to exit tty editors (optional). We have been using the editor built into Cloud9. On a bare-bones machine, you might have to use the vi or emacs editors. A quick introduction to these editors can be helpful for later use.

31. Select the circle plus sign next to a Cloud9 tab and select **New Terminal**.
32. Type vi index.html at the Bash command line prompt.

    The program vi provides syntax highlighting to help you quickly identify different parts of your program. In HTML, **tags** (defined in the next section) appear in orange.

33. Name one tag that you can see.
34. Make a change in the editor as follows. The i key enters insertion mode, and the escape key

exits insertion mode. To save changes and exit vi, type: `x`.

Another popular editor is emacs; you exit emacs with `Ctrl+x Ctrl+c`. Both editors are installed on the Cloud9 server, but you are likely to prefer the ACE code editor that is built in with the environment. You can close the additional terminal tab you opened for this step.

Part IV: A Static Webpage

A static web page is one that does not change in response to user interactions. However, static web pages can provide user interaction by **hyperlinking** to each other. In the next lesson, you will learn how to use JavaScript to provide interactivity with the user within a single web page.

A hyperlink has the following syntax in HTML.

```
<a href="myfile">Text for the link</a>
```

The quoted filename can be a relative reference to a file on the same server as the HTML file containing this hyperlink, or it can be a full URL for any resource on the Web.

35. Create a second web page that says anything you want, as follows.
    - In the file browser at the left of the Cloud9 interface, right-click the `214/skeleton.html` file and select **Duplicate**. Change the name to something appropriate like `yourtopic.html`.
    - You can edit the file in an editor. You can also see a rendered view by either using the Cloud9 Preview mode to open the file or opening the file in your browser served by Apache as described in step 5. Make changes in the editor and save the modified file. Then refresh one of the rendered views of the file.
    - When you are happy with your new page, modify `ice.html` to link to your new web page.

    A static web page is one that does not change in response to user interactions. In a later lesson, we will create web pages that allow for user interaction. For now, you will modify the static web page that you've been working with in this activity.

36. Complete two to four of the following tasks as directed by your teacher:
    - Create a second page that references `icecream.css` but looks different than `ice.html`.
    - Use an internal style sheet to change the background of a whole page to an image of your choice.
    - Use an inline style to make one row in a table appear different than others.
    - Step 18 points out properties and values in the CSS. Research five additional properties and their corresponding values and incorporate them into a page through some combination of external, internal, and inline styles.

    - Use the accompanying *Lesson 2.1 ReferenceCardUNIX-HTML-CSS* and the Internet as necessary to help you create your own multi-page website.

Practice Opportunity for the *Create* Performance Task

The Create Performance Task requires you to demonstrate a program that you created that can be executed. In some sense, HTML and CSS provide instructions to a browser's rendering engine, and those instructions are executed by the rendering engine. However, HTML and CSS are not programming languages, because they do not provide variables nor the `if-then` selection and `for` loop iteration required for most algorithms. With JavaScript learned in the next lesson, you could create an interactive web page for the Create Performance Task. Even with just HTML and CSS, we do use the iterative development and design process and can practice the following component of the Create Performance Task.

- *Describe the incremental and iterative development process you used, focusing on two distinct points in that process. Describe the difficulties and/or opportunities you encountered and how they were resolved or incorporated. (Adapted from Create Performance Task Part 2b.)*

Note: This direction is adapted from the official College Board Create Performance Task but does not duplicate the content of College Board Task or Rubric. The task provided here contains elements that are different than the College Board Performance Task and Rubric. Please reference official College Board materials.

Conclusion Questions

1. What sort of visual options are available to you when deciding how you want your website to appear?
2. What reasons can you imagine for W3C requiring that there be only one `<head>` tag and one `<body>` tag in a given HTML document?
3. The `<img>` tag allows you to provide alternate text to help you reach a wider audience. Give two examples of design decisions that would limit the audience of a web page (i.e., style interfering with content).