University of Illinois at Urbana-Champaign
Dept. of Electrical and Computer Engineering

ECE 101: Computing Technologies and the Internet of Things

Client-Server: Providing Services on the Internet

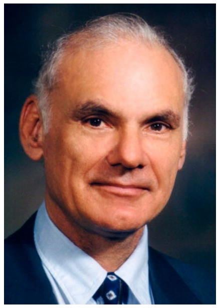
Part 1

© 2023 Steven S. Lumetta, Romit Roy Choudhury, and Abrita Chakravarty. All rights reserved.

What Good is the Internet?

Last week, we talked about the Internet.

Larry Roberts spoke…
…and the Internet connected computers.



Researchers used the Internet
- for more than a decade
- before UIUC made it important
- to the other 99.9% of the world.

A Server Provides Some Sort of Service

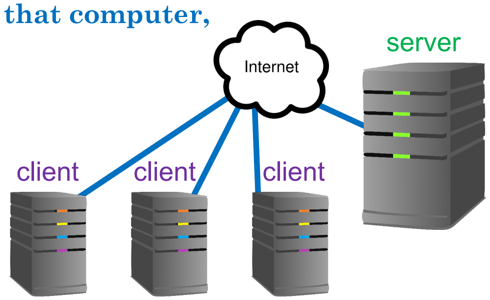
In the Internet, some computer may **provide a certain service**, such as
- providing copies of published IRS tax documents,
- accepting paper submissions to a research conference, or
- computing turbulence in fluid flow around a structure,

We call that computer a **server**.

A Server's Clients Make Use of that Service

Other computers can then communicate over the Internet, **contact that computer, and use the service**.

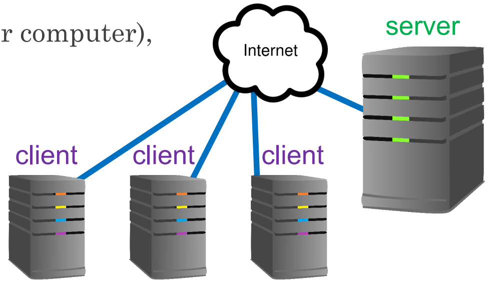
These computers are the **clients** for that server.



Any Computer Can Provide or Use a Service

Note that a **server**
- **may also be a client**
- to another server (another computer),
- and vice-versa.

Client and server are just roles for a given service.



Examples of Early Services

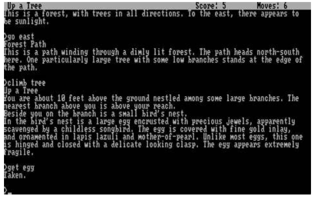
Some **early services** were provided by a program called the Internet daemon (**`inetd`**):
- **`who`** is on the computer now?
  (answers with a list of users)
- **`finger`** a particular user
  (shows their name, office, last login, …)
- **`last`** logins to the computer?
  (a chronological list of user ids along with times of login and logout)

Any computer could be a client…

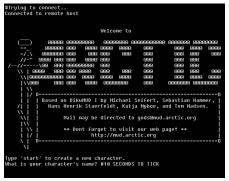
Most Popular Services? Communicating with People!

Other services allowed people to communicate and to share information:
- bulletin boards / network **news**,
- **libraries** with copies of programs, (tools, games, and so forth), and
- electronic mail (**e-mail**).

UUNET Communications Services commercialized these services in 1987.



```
Up a Tree                                        Score: 5      Moves: 6
This is a forest, with trees in all directions. To the east, there appears to
be sunlight.

>go east
Forest Path
This is a path winding through a dimly lit forest. The path heads north-south
here. One particularly large tree with some low branches stands at the edge of
the path.

>climb tree
Up a Tree
You are about 10 feet above the ground nestled among some large branches. The
nearest branch above you is above your reach.
Beside you on the branch is a small bird's nest.
In the bird's nest is a large egg encrusted with precious jewels, apparently
scavenged by a childless songbird. The egg is covered with fine gold inlay,
and ornamented in lapis lazuli and mother-of-pearl. Unlike most eggs, this one
is hinged and closed with a delicate looking clasp. The egg appears extremely
fragile.

>get egg
Taken.

>
```



```
#Trying to connect..
Connected to remote host


                          Welcome to

    Based on DikuMUD I by Michael Seifert, Sebastian Hammer,
      Hans Henrik Staerfeldt, Katja Nyboe, and Tom Madsen.

             Mail may be directed to gods@mud.arctic.org

             ** Dont forget to visit our web page! **
                       http://mud.arctic.org

Type 'start' to create a new character.
What is your character's name? #10 SECONDS TO TICK
```

Internet Itself can be Considered a Service

Is the Internet itself a service?

One can certainly view it that way.

What is the service?

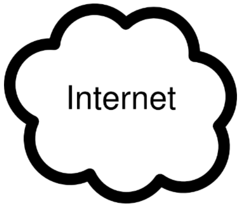
Try to **deliver a packet** of bits (information) to a specified address (IP address).

What are the clients?

Any computer that wants to communicate.

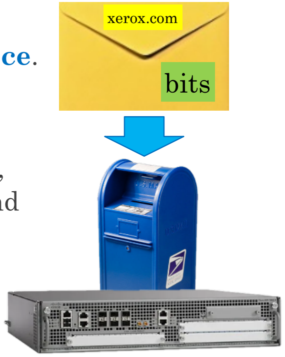
What are the server(s)?

Routers (and Internet Service Providers, and …)



Internet Service Analogous to Postal Delivery

In that sense,
the **Internet** is **like the post office**.

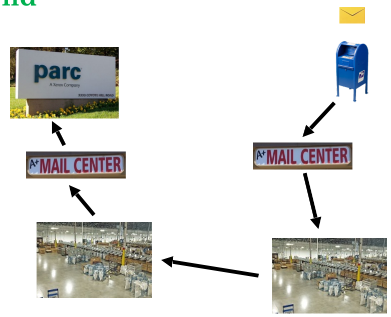


To send bits,
- put your bits into envelopes (packets),
- write the (IP) address on the front, and
- drop them into the nearest router.

Delivering a Letter Requires Many Forwarding Steps

What happens when you send a physical letter?

You drop the letter into a mailbox.
Your letter is taken to a local center.
And forwarded to a regional center.
And to another regional center.
And to a local center near recipient.
And finally to the recipient!

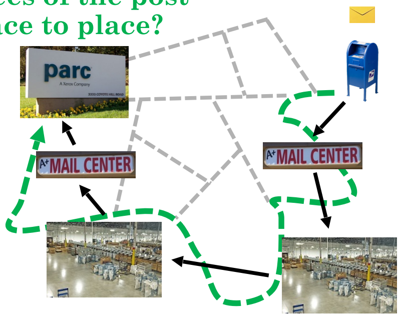


Mail Travels over Some of the Road Network

How do the servers (the employees of the post office) move your letter from place to place?

Using the roads (and sometimes the airways)!

But there are **a lot more roads** that are **not used** by the post office!



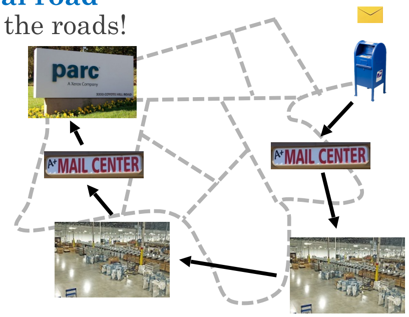
Services Also Define Virtual Networks Over the Internet

The **post office uses** its own **virtual road network** (**black arrows**) on top of the roads!

Now let’s use our analogy in reverse…

Can a service define a virtual network over the Internet?

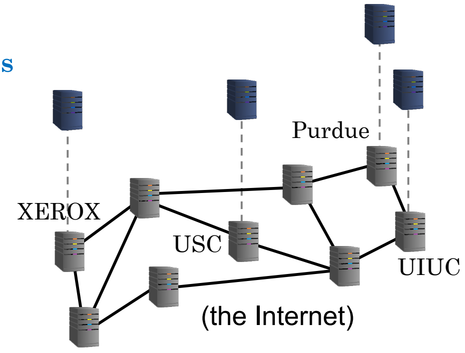
Absolutely! E-mail, for example, **does** just that. Let’s see how.



E-Mail Services Provided by Some Computers

With e-mail, some computers provided mailbox services:
- servers at UIUC and other major universities, and
- servers at some companies.

But **not every computer** was an email server!


Purdue
XEROX
USC
UIUC
(the Internet)

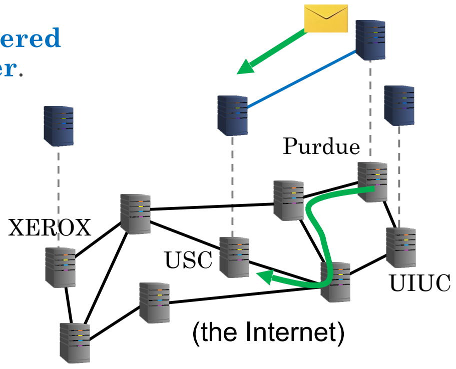
E-Mail Servers Connected through the Internet

To send an e-mail, a **user delivered** a **message to any** e-mail **server**.

For example:
- from jan@purdue.edu
- to pat@xerox.com

The e-mail server **forwarded** the message to another e-mail server …

… **through the Internet**.

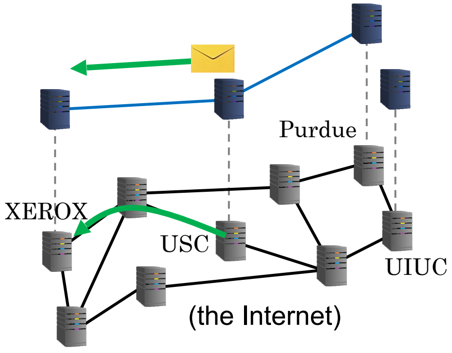

Purdue
XEROX
USC
UIUC
(the Internet)

Messages Move from E-Mail Server to E-Mail Server

That server might forward the message to another server…

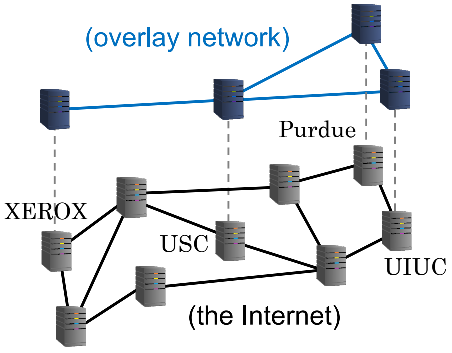
…again, through the Internet…

…until the message reached the destination mailbox.


Purdue
XEROX
USC
UIUC
(the Internet)

Together, E-Mail Servers Form an Overlay Network

The “connections” between e-mail servers
- form an **overlay network**:
- **a subset of nodes**
- **connected by virtual links**
- (also called a virtual network).


(overlay network)
Purdue
XEROX
USC
UIUC
(the Internet)

Next: the World Wide Web Service

Let's look at more examples of services.

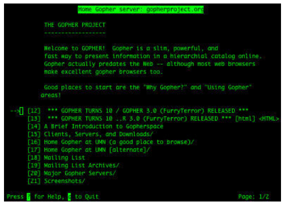
How about the **World Wide Web**…

(which most of you have probably always called "the Internet")?

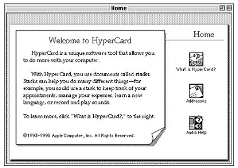
Gopher and HyperCard: Examples of Early Tech

Later Internet services such as **Gopher**
- allowed clients to **explore text documents**
- spread **across multiple servers**
- such as guidance on the requirements for undergraduate curriculum at UIUC.

Apple's **HyperCard**
- enabled users to **move from page to page**
- **by clicking on** a **keyword** or an icon.
- **Sound familiar?**



```
Home Gopher server: gopherproject.org

THE GOPHER PROJECT
------------------

Welcome to GOPHER!  Gopher is a slim, powerful, and
fast way to present information in a hierarchial catalog online.
Gopher actually predates the Web -- although most web browsers
make excellent gopher browsers too.

Good places to start are the "Why Gopher?" and "Using Gopher"
areas!

-->[] [12]  *** GOPHER TURNS 10 / GOPHER 3.0 (FurryTerror) RELEASED ***
      [13]  *** GOPHER TURNS 10 ..R 3.0 (FurryTerror) RELEASED *** [html] <HTML>
      [14] A Brief Introduction to Gopherspace
      [15] Clients, Servers, and Downloads/
      [16] Home Gopher at UMN (a good place to browse)/
      [17] Home Gopher at UMN [alternate]/
      [18] Mailing List
      [19] Mailing List Archives/
      [20] Major Gopher Servers/
      [21] Screenshots/

Press ? for Help, q to Quit                                  Page: 1/2
```



Welcome to HyperCard

HyperCard is a unique software tool that allows you to do more with your computer.

With HyperCard, you use documents called **stacks**. Stacks can help you do many different things—for example, you could use a stack to keep track of your appointments, manage your expenses, learn a new language, or record and play sounds.

To learn more, click "What is HyperCard?," to the right.

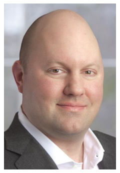
©1993-1995 Apple Computer, Inc. All Rights Reserved.

What Most People View as the Internet Arrived in 1993

These ideas were **combined into a single protocol** (HyperText Transfer Protocol, **HTTP**) in 1989 by Tim Berners-Lee (at CERN).

The **first web browser** (integrating images with text), **Mosaic**, was **developed by Marc Andreessen** and others (at UIUC) in 1992, and made public in 1993.

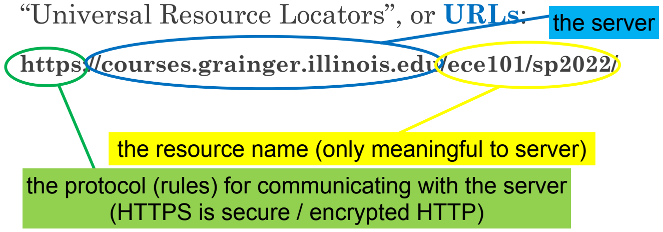
The browser made the Internet interesting to the rest of humanity.



HTTP Protocol Perhaps Familiar to You?

A **web server** is an example of an **Internet service**.

Online resources are named using "Universal Resource Locators", or **URLs**:



https://courses.grainger.illinois.edu/ece101/sp2022/

the server

the resource name (only meaningful to server)

the protocol (rules) for communicating with the server
(HTTPS is secure / encrypted HTTP)

Web Browser is a Client to a Web Server

A **web browser**
- is **client software**
- that enables a human
- **to** make use of **web servers**.

Last week, we talked about how a web browser communicates with a server.

The URL is what a human (or another web page) provides to identify which server to contact.

In a couple of weeks,
- we'll look at web search,
- another Internet service
- that allows one to find interesting URLs.

Clients and Servers Must Interact Correctly

Each **Internet service** is unique:
- **defines what it provides,**
- defines the **rules for clients** to make requests for services, **and**
- defines the **form of answers** and how they are returned to clients.

Clients must know these things—generally, **every service has distinct client software**!