Chapter 9
The Evolving Internet

ARPANET Pioneers Build a Reliable Network

Out of Unreliable Parts

✓ The Advanced Research Projects Agency NETwork (ARPANET) is the predecessor to the Internet:
  ➢ Developed at the request of the Department of Defense by a team of visionary computer scientists
  ➢ Launched in 1969
  ➢ Peer-to-peer networking philosophy and protocols were copied in other networks in the 1980s
  ➢ Disbanded in 1990, having fulfilled its research mission, but its technology spawned the Internet

Packet switching

During the 1960s, Paul Baran (RAND Corporation), produced a study of surviveable networks for the US military.

Independently, Donald Davies (National Physical Laboratory, UK), proposed and developed a similar network based on what he called packet-switching, the term that would ultimately be adopted.

Leonard Kleinrock (MIT) developed mathematical theory behind this technology.

Tommy Krash and Paul Baran used US Military funded research to focus on using message-blocks to include network redundancy, which in turn led to the widespread urban legend that the Internet was designed to resist nuclear attack

ARPANET

Len Kleinrock implemented the first Interface Message Processor.

The first ARPANET link was established between the University of California, Los Angeles and the Stanford Research Institute on 22:30 hours on October 29, 1969.

ARPANET became the technical core of what would become the Internet, and a primary tool in developing the technologies used.

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1970s

BIRTH OF THE INTERNET

THE ARCHITECTURE OF THE INTERNET AND THE DESIGN OF
THE CORE INTERNETWORKING PROTOCOL TCP (WHICH LATER BECAME TCP/IP)
WERE CONCEIVED BY VINTON G. CERF AND ROBERT E. KAHN DURING 1973
WHILE CERF WAS AT STANFORD'S DIGITAL SYSTEMS LABORATORY AND
KAHN WAS AT ARPA (LATER DARPA). IN THE SUMMER OF 1976, CERF LEFT STANFORD
TO MANAGE THE PROGRAM WITH KAHN AT ARPA.

THEIR WORK BECAME KNOWN IN SEPTEMBER 1973 AT A NETWORKING CONFERENCE IN ENGLAND.
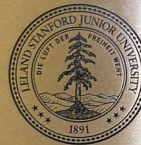CERF AND KAHN'S SEMINAL PAPER WAS PUBLISHED IN MAY 1974.

CERF, YOGEN K. DALAL, AND CARL SUNSHINE
WROTE THE FIRST FULL TCP SPECIFICATION IN DECEMBER 1974.
WITH THE SUPPORT OF DARPA, EARLY IMPLEMENTATIONS OF TCP (AND IP LATER)
WERE TESTED BY BOLT BERANEK AND NEWMAN (BBN),
STANFORD, AND UNIVERSITY COLLEGE LONDON DURING 1975.

BBN BUILT THE FIRST INTERNET GATEWAY, NOW KNOWN AS A ROUTER, TO LINK NETWORKS TOGETHER.
IN SUBSEQUENT YEARS, RESEARCHERS AT MIT AND USC-ISI, AMONG MANY OTHERS,
PLAYED KEY ROLES IN THE DEVELOPMENT OF THE SET OF INTERNET PROTOCOLS.

KEY STANFORD RESEARCH ASSOCIATES AND FOREIGN VISITORS

VINTON CERF

DAG BELSNES	JAMES MATHIS
RONALD CRANE	BOB METCALFE
YOGEN DALAL	DARRYL RUBIN
JUDITH ESTRIN	JOHN SHOCH
RICHARD KARP	CARL SUNSHINE
GERALD LE LANN	KUNINOBU TANNO

DARPA

ROBERT KAHN

COLLABORATING GROUPS

BOLT BERANEK AND NEWMAN
WILLIAM PLUMMER · GINNY STRAZISAR · RAY TOMLINSON

MIT
NOEL CHIAPPA · DAVID CLARK · STEPHEN KENT · DAVID P. REED

NDRE
YNGVAR LUNDH · PAAL SPILLING

UNIVERSITY COLLEGE LONDON
FRANK DEIGNAN · MARTINE GALLAND · PETER HIGGINSON
ANDREW HINCHLEY · PETER KIRSTEIN · ADRIAN STOKES

USC-ISI
ROBERT BRADEN · DANNY COHEN · DANIEL LYNCH · JON POSTEL

ULTIMATELY, THOUSANDS IF NOT TENS TO HUNDREDS OF THOUSANDS
HAVE CONTRIBUTED THEIR EXPERTISE TO THE EVOLUTION OF THE INTERNET.

DEDICATED JULY 28, 2005

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Counting Connections

- ✓ The **Internet:** an interconnected network of thousands of networks
  - ➢ Links academic, research, government, and commercial institutions
- ✓ Connects computers to about every country in the world
  - ➢ Growing too fast to measure its growth
  - ➢ Internet is decentralized
  - ➢ Internet doesn't have hard boundaries

Internet Protocols

- Transmission Control Protocol/Internet Protocol, **TCP/IP…**

- TCP breaks messages into packets.
  - Each packet has all the information needed to travel from network to network.
  - Host systems called **routers** determine how to route transmissions.
  - Packet-switching is flexible and robust.

Internet Protocols

- ✓ IP address is the address for the packets.
  - ➤ Each Internet host computer has a unique IP address (IPv4).
  - ➤ Each address is comprised of four sets of numbers separated by periods, such as 123.23.168.22.
  - ➤ NextGeneration IPv6 addressing will allow more addresses and multicasting.

Domain Name System (invented in 1983) is the "phone book" for the Internet. It transles human-friendly computer hostnames into Internet Protocol addresses. For example, www.csudh.edu translates to the addresses 155.135.55.165 (IPv4).

Internet Addresses

155.135.55.156 csc.csudh.edu

155.135.55.165 csudh.edu

74.125.227.16 google.com

Internet Addresses

DNS Tools (resolve IP addresses and DSN addresses)

http://www.dnstools.com/

Internet Addresses

- ✓ The host is named using DNS (domain name system), which translates IP addresses into a string of names.
- ✓ Top-level domains include:
  - ➤ .edu - educational sites
  - ➤ .com - commercial sites
  - ➤ .gov - government sites
  - ➤ .mil - military sites
  - ➤ .net - network administration sites
  - ➤ .org - nonprofit organization sites

Internet Addresses

- .aero   Air transport organizations

- .biz   Businesses

- .coop   Cooperative businesses such as credit unions

- .info   Information services

- .museum Museums

- .name   Personal registration by name

- .pro   Licensed professionals, including lawyers, doctors,   and accountants

Inside the Internet

✓ An email address includes: username@hostname.sub.dom

   ➢ **username** is the person's "mailbox"

   ➢ **hostname** is the name of the host computer and is followed by one or more domains separated by periods:

      ☐ host.domain

      ☐ host.subdomain.domain

      ☐ host.subdomain.subdomain.domain

Inside the Internet

benjamin@cs.orst.edu
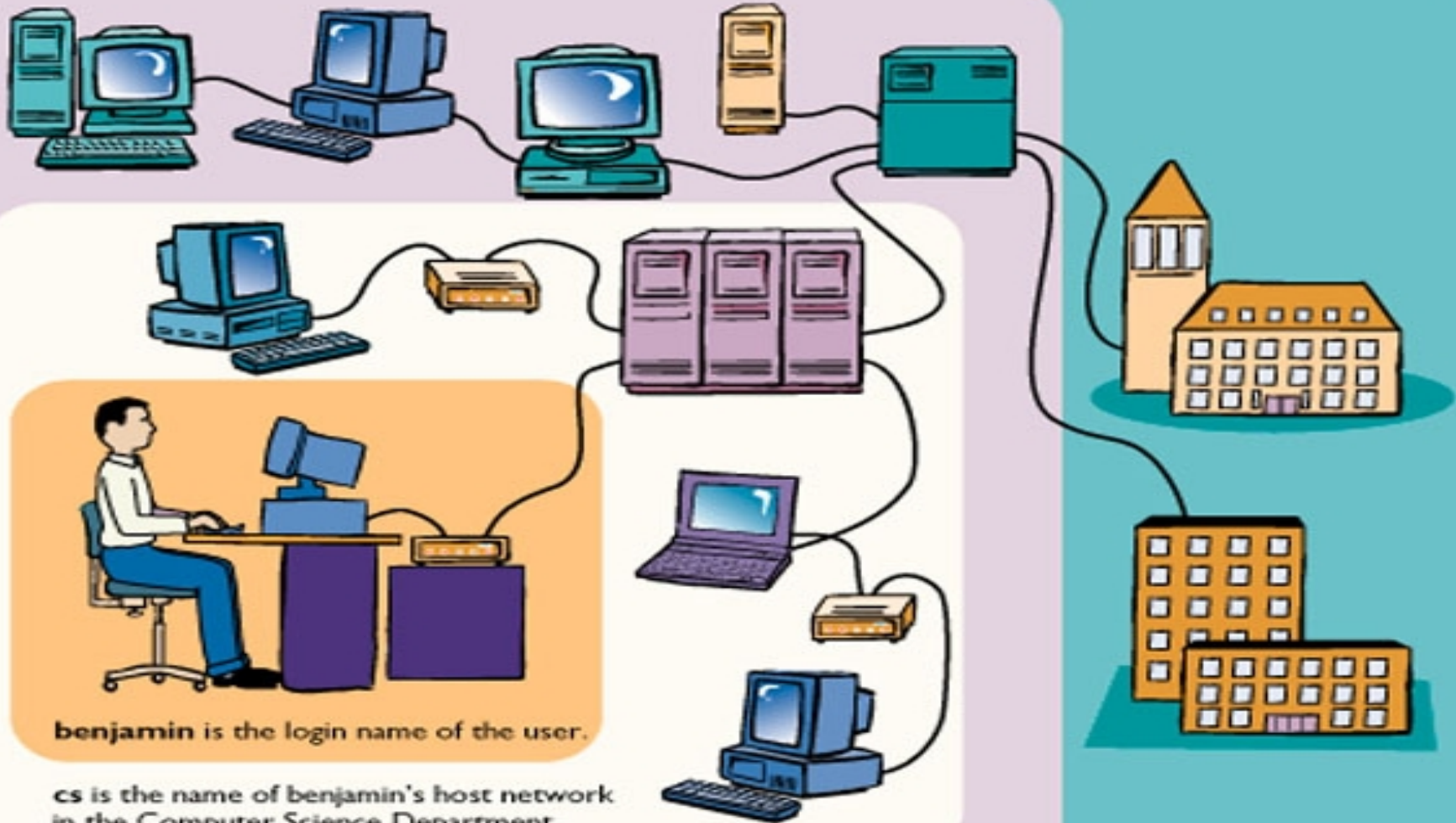
benjamin is the login name of the user.

cs is the name of benjamin's host network in the Computer Science Department.

orst is the domain name for Oregon State University's LAN, which includes the cs LAN.

edu is the name of the top-level domain containing Internet educational sites.

Inside the Internet

User **President** whose mail is stored on the host **whitehouse** in the **government** domain

president@whitehouse.gov

User **hazel_filbert** at the **admin** server for Grant MacEwan Community College in Alberta, Canada

hazel_filbert@admin.gmcc.ab.ca

Inside the Internet
Internet Access Options

✓Direct (Dedicated) Connection
- ➤Computer has its own IP address and is attached to a LAN
- ➤No need to dial up
- ➤Files are stored on your computer
- ➤Quick response time

✓Dialup Connection
- ➤Limited connection using a modem
- ➤Full access dialup uses POTS or PPP via modem

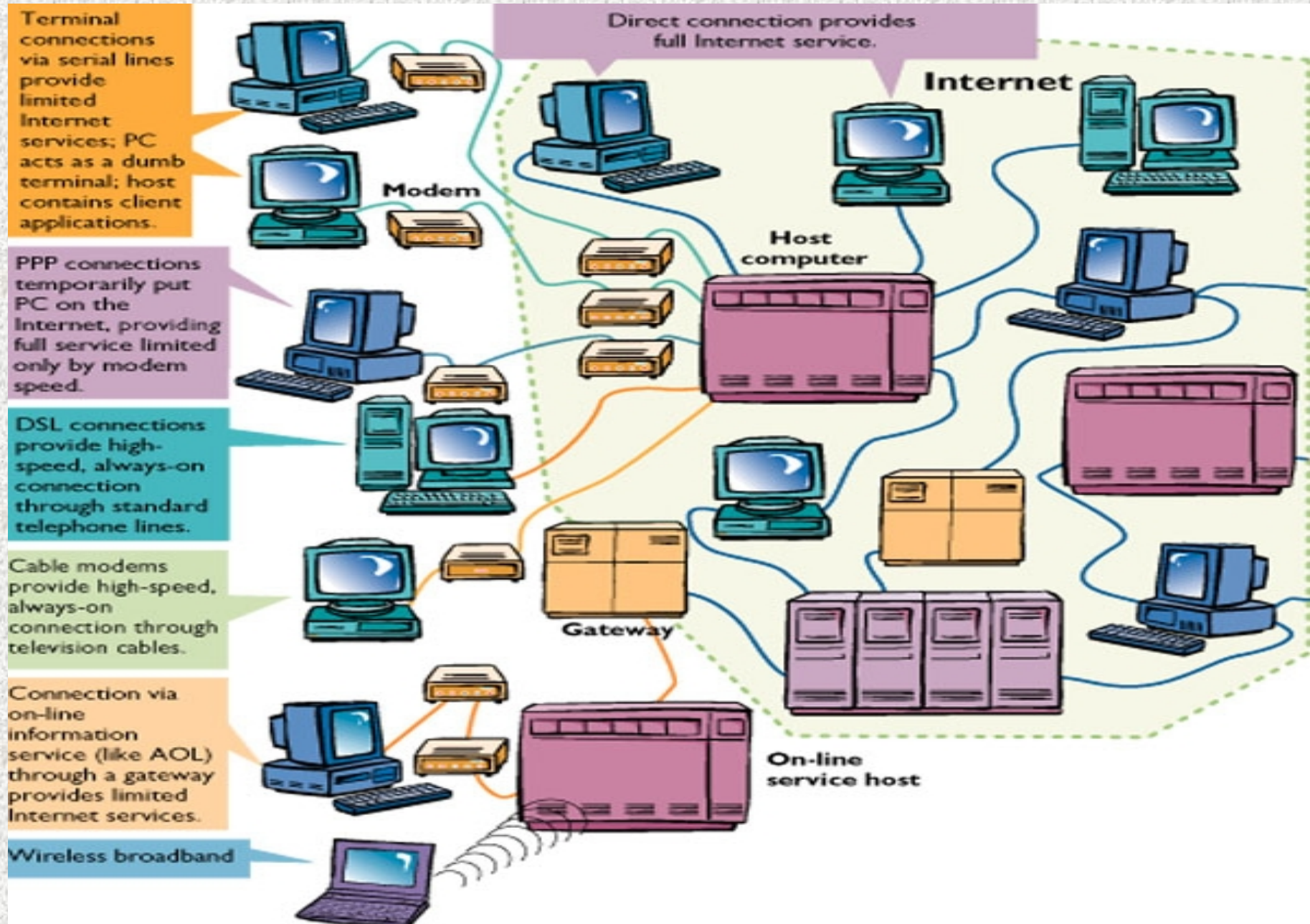# Internet Access Options

✓ Broadband Connections

   ➢ DSL Service

     ❑ Newer, faster, and cheaper than ISDN

     ❑ Can share phone line with voice traffic

   ➢ Cable Modem Connection

     ❑ Allows Internet connections using shared TV cables

     ❑ Can exceed DSL speeds

     ❑ Carries increased privacy and security risks

Inside the Internet

Terminal connections via serial lines provide limited Internet services; PC acts as a dumb terminal; host contains client applications.

PPP connections temporarily put PC on the Internet, providing full service limited only by modem speed.

DSL connections provide high-speed, always-on connection through standard telephone lines.

Cable modems provide high-speed, always-on connection through television cables.

Connection via on-line information service (like AOL) through a gateway provides limited Internet services.

Wireless broadband

Direct connection provides full Internet service.

Internet

Modem

Host computer

Gateway

On-line service host

Internet Access Options

- **Satellite connection** provides connection using satellite dishes.
- **Wireless broadband connection** allows multiple computers to connect to a base station using short-range radio waves.

Internet Service Providers (ISPs)

- Local ISPs provide connections through local telephone lines.
- National ISPs offer connections on a nationwide scale.
- Online Services (like AOL, Google, MSN, and Yahoo!) offer extra services.

Internet Servers

➢ **E-mail server** acts like a local post office for a particular Internet host—a business, an organization, or an ISP.

➢ **File servers** are common within LANs.

❑ Also used to share programs, media files, and other data across the Internet

➢ **File transfer protocol (FTP)** allows users to transfer files.

❑ Download files from remote servers to their computers

❑ Upload files to remote computers

❑ File compression saves storage space on disk and saves transmission time when files are transferred through networks.
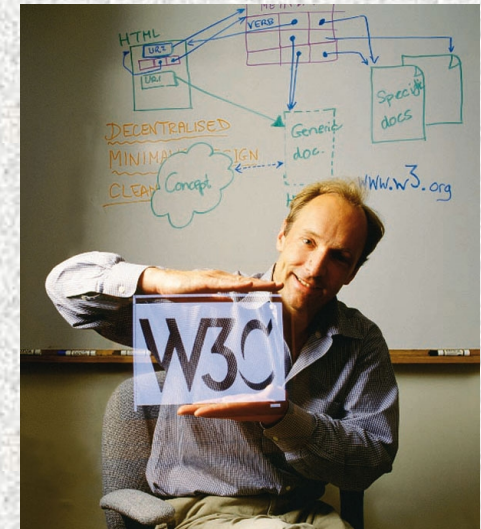
Internet Servers

➢**Application server** stores applications—PC office applications, databases, or other applications.
- ❑Makes them available to client programs that request them
- ❑Might be housed at an application service provider (ASP), a company that manages and delivers application services on a contract basis

➢**Web server** stores Web pages and sends pages to client Web browsers.
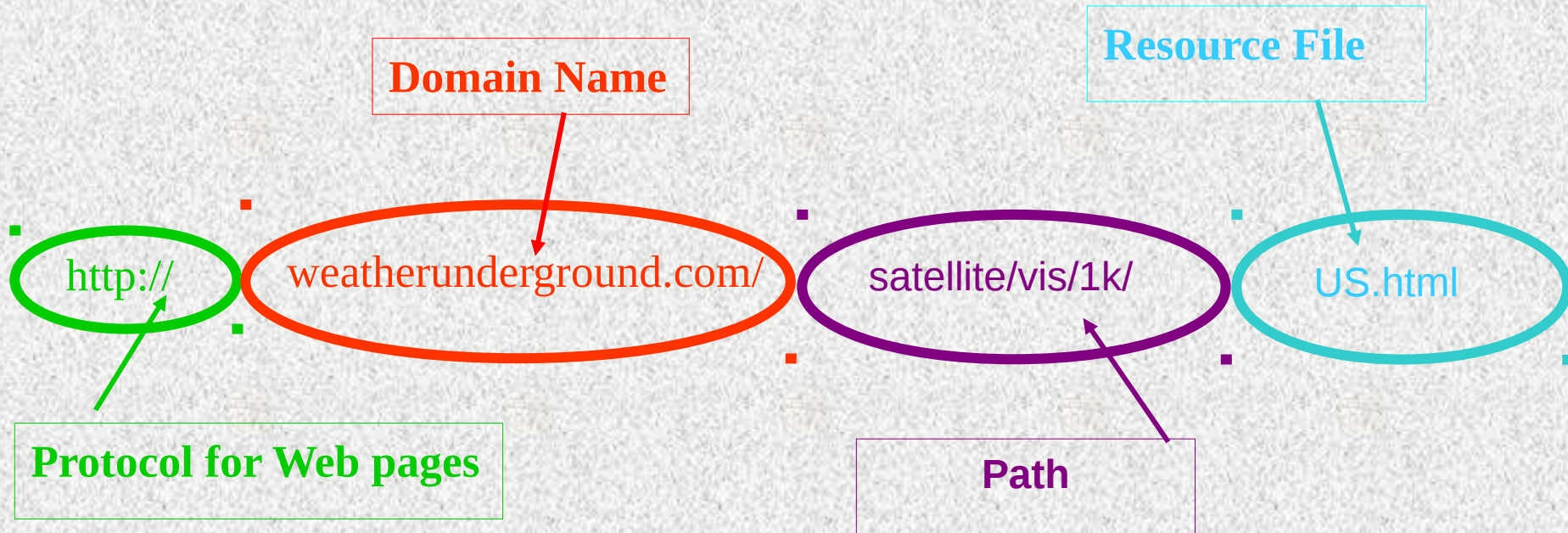
Tim Berners-Lee Weaves the Web for Everybody

✓ Wanted to create an open-ended distributed hypertext system with no boundaries, so scientists everywhere could link their work together

✓ Invented and implemented the World Wide Web based on (already known) Internet and HTTP.

✓ WWW may be described as a service (application) that runs on the Internet.

Web Protocols: HTTP and HTML

✓ HTTP (Hypertext transfer protocol) used to transfer Web pages

Domain Name

Resource File

http://   weatherunderground.com/   satellite/vis/1k/   US.html

Protocol for Web pages

Path

✓ HTML (HyperText Markup Language) created for encoding and displaying documents

Search Engines

- ✓ Search engines are designed to make it easier to find information on the Web.
  - ➢ **Web Crawlers** or **Spiders**
    - ❑ Software robots that systematically search the Web
- ✓ Some search engines use keywords and Boolean logic to conduct searches.
- ✓ Other search engines conduct searches using a hierarchical directory or subject tree.

Search Engines

- ✓ startpage.com
- ✓ duckduckgo.com
- ✓ alexa.com (also provides traffic analysis)
- ✓ bing.com
- ✓ altavista.com
- ✓ metacrawler.com

The Google Guys Search for Success

✓ Google is one of the most successful companies on WWW.
- ➢ Search for Web pages, facts, quotes, etc.
- ➢ 200 million queries a day
- ➢ Makes money on digital
advertising and marketing

✓ Launched by a Sergey Brin and Larry Page *(Stanford Ph.D. students)*
- ➢ New approach in search technology
- ➢ Marks a page's relevance by the number of times other related web pages link to it, not how often a word or phrase appeared on a page

Google headquarters viewed using Google Earth, a free application that combines satellite imagery, maps, and Google's search engine.

Internet Issues: Ethical and Legal Dilemmas

✓ Privacy:

Schmidt: Don't Like Google Street View Photographing Your House? Then Move.

http://digitaldaily.allthingsd.com/20101025/schmidt-dont-like-google-street-view-photographing-your-house-then-move/

Internet Issues: Ethical and Legal Dilemmas

✓ Censorship:
Criticism of Google

http://webcache.googleusercontent.com/s
earch?q=cache:h0ZwkXkEO64J:en.wikipedia
.org/wiki/Criticism_of_Google+google+ce
nsorship+china&cd=3&hl=en&ct=clnk&gl=us

Internet Issues: Ethical and Legal Dilemmas

✓ Computer crime:

✓ Outsourcing of computer jobs

✓ Massive theft of intellectual property

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Chapter 9
Lesson Summary

✓ The Internet is a network of networks that connects all kinds of computers around the globe and uses standard protocols to allow Internet communication to occur.

✓ No single organization owns or controls the Internet.

✓ You can connect to the Internet in several ways that provide different degrees of access to Internet services.

✓ Most Internet applications are based on the client/server model.

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Chapter 9
Lesson Summary (continued)

✓ The Web uses a set of protocols to make a variety of Internet services and multimedia documents available to users through a simple point-and-click interface.

✓ In addition to Web sites, a variety of applications are built on the protocols of the Internet and the Web. For example, people who use the Web depend on search engines to find the information they need.

✓ Peer-to-peer computing was popularized by music-sharing services, but its applications go beyond music sharing.

✓ Many businesses are exploring ways to apply P2P technology.

✓ Grid computing goes beyond P2P computing by enabling people to share processor power.

✓ As the Internet grows and changes, issues of privacy, security, censorship, criminal activity, universal access, and appropriate Net behavior are surfacing.