EMT2455 Data Communications

§ 1. Introduction to the Internet

Dr. Xiaohai Li
xhli@citytech.cuny.edu
Dept. of Computer Engineering Technology
New York City College of Technology

Last Update: September 2014
Copyright Notice

- The slides include pictures, figures, diagrams, tables and other contents from a variety of sources. Use them for educational purpose ONLY. Copyrights are reserved by their original authors and/or publishers.

- Copyright of all other contents is reserved.
Contents

- What is the Internet?
- When and how did the Internet appear?
- Who built the Internet?
- How the Internet is built?
State-of-the-arts of the Internet

- Hundreds millions nodes, billions of users....
- Internet of Things (IOT): All different types of nodes are being connected.
- Part of our daily life.
- It is a big deal! No need to brag about this.
- Even Astronauts are using it in the International Space Station.
- Even North Korea gets it!
What are the Internet?

- Can I say “Internet is made by a huge bunch of websites?”
- What applications the Internet has, or what you can do on the Internet?
- What are websites/web server, web browser (IE, FireFox, Google Chrome), and WWW (world wide web)?
- Which one appeared first? Internet or WWW?
- What is TCP/IP? What is its role?
- What is HTTP? What it does?
- What GoDaddy does? What Verizon, Time Warner Cable, ATT, Optimum do?
- Who manages all IP addresses for the Internet?
- Who authorizes a domain name ending with “.info”, “.us” or “.nyc”? 
Applications of the Internet

- Traditional core applications:
  - Email
  - BBS
  - Remote Login (Telnet)
  - File Transfer (FTP)

- The killer application:
  - World-Wide Web (WWW)

- New applications:
  - Videoconferencing, Social networking,
  - Twittering, Blogging, Skype, P2P applications, Internet
  - Broadcast, Virtual Life, ... ...
Starting Point: ARPANET

- Thanks to Soviet Union: 1957 – USSR launched Sputnik I, the 1st satellite. United States were shocked
- Advanced Research Projects Agency, ‘ARPA’ (now: DARPA of DoD) was founded
  - Thechnological think-tank and Program/Project sponsor
  - Space race, ballistic missiles, nuclear, bioweapon, ..., and many more top secret programs
Who invented the Internet?

- Al Gore? No 😊
- Not invented by a single person/team
- Leonard Kleinrock who did the pioneering work in packet switching?
- Vint Cerf and Robert Kahn who defined the "Internet Protocol" (IP) and participated in the development of TCP?
- Tim Berners-Lee who developed HTTP to support a global hyper-text system he called the World Wide Web? (Internet vs the World Wide Web?)

- 1961 – First research paper on packet switching published: “Information Flow in Large Communication Nets”, Leonard Kleinrock (was MIT graduate student)

- Packet Switching: one of the core technologies in telecommunication, data communication, networking and Internet.

- Circuit Switching: old technology
1966 – 1968: Experiment of Connecting Computers

1966 – Lawrence Roberts (colleague of Kleinrock from MIT) publishes overall plan for an ARPAnet (a packet switch network)

1968 – ARPA awards contracts for four nodes in ARPANET to UCLA (Network Measurement), Stanford Research Institute (Network Information Center), UCSB (Interactive Mathematics) and U Utah (Graphics)
1969: First Connections

- 9/2/1969 – Leonard Kleinrock’s computer at UCLA becomes first node on the ARPANET

- 10/29/1969 – First network link established! Charlie Kline attempts use of remote login from UCLA to SRI; system crashes as “G” in entered
1967-1971: So what do we do with it?

- 1967-1972 – Vinton “Vint” Cerf, graduate student in Kleinrock’s lab, works on application level protocols for the ARPANET (file transfer and Telnet protocols)

- 1971 - Ray Tomlinson writes email application
1971-1973

Networks Growing

- 1970 - First cross-country link installed by AT&T between UCLA and BBN at 56kbps
- Other networks: ALOHAnet (microwave network in Hawaii), Telenet (commercial, BBN), Transpac (France)
- 1973 – Ethernet was designed in 1973 by Bob Metcalfe at Xerox Palo Alto Research Center (PARC)
- Internetworking: How can these networks be connected together?
1972-1974: Protocol Development

- 1972-1974 – Robert Kahn and Vinton Cerf, “Fathers of the Internet”, develop protocols (TCP/IP) to connect networks without any knowledge of the topology or specific characteristics of the underlying nets.

- 1972 – Robert Kahn gives first public demonstration of ARPAnet (now 15 nodes) at International Conference on Computer Communication
1974-1978: Development of TCP/IP

- 1974 – First full draft of TCP produced
- November 1977 - First three-network TCP/IP based interconnection demonstrated linking SATNET, PRNET and ARPANET in a path leading from Menlo Park, CA to Univ. College London and back to USC/ISI (Marina del Ray, CA)
- 1978 – TCP and IP fully drafted, now called TCP/IP suite
1981 – 1984: Base Protocols In Place

- 1981 – Term “Internet” coined to mean collection of interconnected networks
- 1982 – ISO releases OSI seven layer model; actual protocols die but model is influential
- 1984 – Cisco Systems Inc. founded. Cisco now is the most dominant manufacturer of network router and switch in the world.
1983-1986: Not Just a Research Project Anymore

- 1984 – Domain Name System (DNS) introduced; 1000+ hosts (200 hosts by end of 1970s; over 100000 by end of 1980s)
- 1986 – NSFNET created to provide access to 5 super computer centers including Theory Center at Cornell (NSFNET backbone speeds 56 Kbps)
- 1983 – ARPANET split into ARPANET and MILNET; MILNET to carry defense related traffic
1988-1989: Growing Pains?

- November 1988 – Internet worm affecting about 10% of the 60000 computers on the Internet (Robert Morris, Cornell)

- 1988 - Internet Assigned Numbers Authority (IANA) established in December with Jon Postel as its Director. Postel was also the RFC Editor and US Domain registrar for many years
1990-1993: Legendary WWW

- 1990 – ARPANET ceases to exist
- 1990 – Tim Berners-Lee develops hypertext system with initial versions of HTML and HTTP and first GUI web browser called “World Wide Web”
- 1993 – Mosaic, a GUI web browser, written by Marc Andreessen and Eric Bina at NCSA takes world by storm (showed in-line images and was easy to install);
- WWW proliferates at a 341,634% annual growth rate of service traffic
1990-1993: Ready for Public Consumption

- 1990 – First ISP world.std.com
- 1991 – NSFNET lifted restrictions on use of NSFNET for commercial purposes
- 1992 – Internet Society (ISOC) founded
- 1993 – InterNIC created by NSF to provide Internet services; Private companies transition into roles (AT&T – directory and database services; Network Solutions – registration services; CERFnet – information services)
1990’s: Booming but still far from now

- 1995- NSFNET reverts back to a research network. Main US backbone traffic now routed through commercial internet service providers
- 1995 – Sun launches Java
- 1995 - Traditional online dial-up systems (Compuserve, America Online, Prodigy) begin to provide Internet access
- 1995 - Registration of domain names no longer free
1990’s: Booming but still far from now

- 1994 – Hotmail starts web based email
- 1994 – World Wide Web Consortium (W3C) was founded
- 1995 – NSF stops funding of NSFNET. The Internet is completely commercial.
- 1996 – Mirabilis (Israel) starts ICQ
- 1999 -- First online banking business.com sold for $7.5M.
- 1999 - Napster released.
- 1995-2000 eBuisiness boomed, “Internet bubble”
Now

- 1998 – Google is founded by Larry Page and Sergey Brin
- Netflix
- Facebook
- Twitter
- ......
Time Line of the Internet

Source: Internet Society

EMT2455

Dr. Li
Summary: Historical Stages of the Internet

- Started as ARPANET in 1969
- Development of TCP/IP in 1970’s
- From ARPANET to NSFNET, the Internet
- DNS
- Appearance of World Wide Web in 1990
- Booming from WWW during 1990’s
- New applications today
- Future
On October 24, 1995, the Federal Networking Council FNC unanimously passed a resolution defining the term "Internet". The Federal Networking Council (FNC) agrees that the following language reflects our definition of the term "Internet": "Internet" refers to the global information system that --

(i) is logically linked together by a globally unique address space based on the Internet Protocol (IP) or its subsequent extensions/follow-ons;
(ii) is able to support communications using the Transmission Control Protocol/Internet Protocol (TCP/IP) suite or its subsequent extensions/follow-ons, and/or other IP-compatible protocols; and
(iii) provides, uses or makes accessible, either publicly or privately, high level services layered on the communications and related infrastructure described herein.
## Internet Pioneers

<table>
<thead>
<tr>
<th>Paul Baran</th>
<th>Ted Nelson</th>
<th>Leonard Kleinrock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lawrence Roberts</td>
<td>Steve Crocker</td>
<td>Jon Postel</td>
</tr>
<tr>
<td>Vinton Cerf</td>
<td>Robert Kahn</td>
<td>Christian Huitema</td>
</tr>
<tr>
<td>Brian Carpenter</td>
<td>Tim Berners-Lee</td>
<td>Mark Andreesen</td>
</tr>
</tbody>
</table>
Who is the “Man” on the Internet?

- **Internet Society (ISOC):** Founded in 1992, an international nonprofit professional organization that provides administrative support for the Internet. ISOC is the organizational home for the standardization bodies of the Internet.

- **Internet Engineering Task Force (IETF):** Forum that coordinates the development of new protocols and standards. Organized into working groups that are each devoted to a specific topic or protocol. Working groups document their work in reports, called Request For Comments (RFCs).

- **IRTF (Internet Research Task Force):** The Internet Research Task Force is a composed of a number of focused, long-term and small Research Groups.

- **Internet Architecture Board (IAB):** A technical advisory group of the ISOC, provides oversight of the architecture for the protocols and the standardization process.

- **The Internet Engineering Steering Group (IESG):** The IESG is responsible for technical management of IETF activities and the Internet standards process. Standards. Composed of the Area Directors of the IETF working groups.
Internet Standardization Process

- Working groups present their work of the Internet are published as RFC (Request for Comments). RFCs are the basis for Internet standards.

- Not all RFCs become Internet Standards! (There are >3000 RFCs and less than 70 Internet standards)

- A typical (but not only) way of standardization is:
  - Internet Drafts
  - RFC
  - Proposed Standard
  - Draft Standard (requires 2 working implementation)
  - Internet Standard (declared by IAB)
Who gives the university the domain name as “cuny.edu”
Who assigns the network prefix “128.143.0.0/16”?
Who assigns port 80 as the default port for web servers?

The functions associated with the assignment of numbers is referred to as Internet Assigned Number Authority (IANA).

IANA used to be managed by Jon Postel at ISI

Since the 1990s, IP addresses and domain name allocation are delegated to independent organizations. Different organizations are responsible for allocating domain names and IP addresses
IANA

- IANA serves as a registry that keeps records of assigned numbers:
  - IP addresses
  - Protocol numbers
  - Domain names (until 1992)

- There is no charge for allocation.
Transitioning of Domain Name Registration

- **Until 1992:** Domain name registration done as part of IANA
- **1992:** InterNIC was created in a partnership between US government and companies to organize and maintain the growing DNS registry and services. The company Network Solutions ran the administration of InterNIC. Until 1998, Network Solutions had a monopoly for domain names.
- **1995:** InterNIC started charging for domain names ($100 for 2 years)
- **1997:** President Clinton directs the Secretary of Commerce to privatize the management of the domain name system (DNS) in a manner that increases competition and facilitates international participation in its management.
- **1998:** ICANN was created in response to a policy statement issued by the US Department of Commerce that called for the formation of a private sector not-for-profit Internet stakeholder to administer policy for the Internet name and address system. ICANN operates under a contract with the US Department of the Commerce.
ICANN

- The **Internet Corporation for Assigned Names and Numbers (ICANN)** is an internationally organized, non-profit corporation that performs the IANA functions.
  - ICANN is IANA’s “subcontractor”
  - Created in 1998, was located in USC, CA, now headquartered in Playa Vista of LA.
  - ICANN accredits domain-name registrar for .com, .org., .net (and other domain)
  - Responsible for Internet Protocol (IP) address space allocation, protocol identifier assignment, Top-Level Domain name system management, and root server system management.
- Since ICANN performs the IANA functions, it is in charge for allocating all numbers. However, the main concern is the allocation of domain names.
Regional Internet Registries (RIRs)

- Registration and management of IP address out of the US is done by Regional Internet Registries (RIRs)
- There are currently 5 RIRs worldwide:
  - **APNIC** (Asia Pacific Network Information Centre, located in Brisbane, Aus, for Asia/Pacific Region),
  - **ARIN** (American Registry for Internet Numbers, North America, North Atlantic & Caribbean islands),
  - **LACNIC** (Latin America and some Caribbean Islands)
  - **RIPE NCC** (Réseaux IP Européens Network Coordination Centre, Europe, the Middle East, Central Asia).
  - **AfriNIC** (African Regional Registry for Internet Number Resources)
Regional Internet Registries (RIRs)

- Where do RIRs get their addresses from: **IANA** maintains a high-level registry that distributes large blocks to RIRs

- RIR are administer allocation of:
  - IPv4 and IPv6 address blocks
  - Autonomous system (AS) numbers
Contents

- What is the Internet?
- When and how did the Internet appear?
- Who built the Internet?
- How the Internet is built?
  -- Backbone of the Internet: see Ch2.
References

- https://www.iana.org/about
- https://www.icann.org/resources/pages/welcome-2012-02-25-en
- http://www.internetsociety.org/internet
- http://www.internetsociety.org/internet/how-it-works/technical-aspects