History of Networking

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Overview

- Review the History of Networking

- Internet History and Growth
  - William F. Slater, III, Chicago Chapter of the Internet Society
    - [https://www.internetsociety.org/sites/default/files/2002_09_18_Internet_History_and_Growth.ppt](https://www.internetsociety.org/sites/default/files/2002_09_18_Internet_History_and_Growth.ppt)

- The History of the Internet
  - Gary Hunter, Dept. of Marketing, Ukentucky
    - [http://www.uky.edu/Classes/MKT/390/slides/history.ppt](http://www.uky.edu/Classes/MKT/390/slides/history.ppt)

- The Role of DARPA
  - Ed Lazowska, Bill & Melinda Gates Chair, CSE, UWash
    - [http://courses.cs.washington.edu/courses/csep590/06au/lectures/slides/Lazowska_Nov_15.ppt](http://courses.cs.washington.edu/courses/csep590/06au/lectures/slides/Lazowska_Nov_15.ppt)

- Ethics in Computer Networks

- Networking Steve’s Used
Internet History and Growth

William F. Slater, III
Chicago Chapter of the Internet Society
September 2002
Agenda

• Internet History
• Internet Evolution
• Internet Pioneers
• Internet Growth - Sept. 1969 - Sept. 2002
• Conclusion
What Was the “Victorian Internet”? 
What Was the “Victorian Internet”

- The Telegraph
- Invented in the 1840s.
- Signals sent over wires that were established over vast distances
- Used extensively by the U.S. Government during the American Civil War, 1861 - 1865
- Morse Code was dots and dashes, or short signals and long signals
- The electronic signal standard of +/- 15 v. is still used in network interface cards today.
Famous Quote From Sir Isaac Newton

• “If I have been able to see farther than others, it was because I stood on the shoulders of giants.”
What Is the Internet?

• A network of networks, joining many government, university and private computers together and providing an infrastructure for the use of E-mail, bulletin boards, file archives, hypertext documents, databases and other computational resources

• The vast collection of computer networks which form and act as a single huge network for transport of data and messages across distances which can be anywhere from the same office to anywhere in the world.

Written by William F. Slater, Ill
1996
President of the Chicago Chapter of the Internet Society
What is the Internet?

- The largest network of networks in the world.
- Uses TCP/IP protocols and packet switching.
- Runs on any communications substrate.

From Dr. Vinton Cerf, Co-Creator of TCP/IP
Brief History of the Internet

- **1968** - DARPA (Defense Advanced Research Projects Agency) contracts with BBN (Bolt, Beranek & Newman) to create ARPAnet
- **1970** - First five nodes:
  - UCLA
  - Stanford
  - UC Santa Barbara
  - U of Utah, and
  - BBN
- **1974** - TCP specification by Vint Cerf
- **1984** - On January 1, the Internet with its 1000 hosts converts en masse to using TCP/IP for its messaging
A Brief Summary of the Evolution of the Internet

1945

Silicon Chip
Envisioned 1962

First Vast
Computer
Network

ARPANET
Created 1969

Hypertext
Invented 1969

TCP/IP
Invented 1972

TCP/IP
Created 1984

Internet
Named 1989

WWW
Created 1993

Age of
eCommerce
Begins 1995

1995

Mathematical
Theory of
Communication

1948

Packet
Switching
Invented 1965

Memex
Conceived 1945
### From Simple, But Significant Ideas Bigger Ones Grow 1940s to 1969

<table>
<thead>
<tr>
<th>1945</th>
<th>1969</th>
</tr>
</thead>
<tbody>
<tr>
<td>We can access information using electronic computers</td>
<td></td>
</tr>
<tr>
<td>We do it reliably with “bits”, sending and receiving data</td>
<td></td>
</tr>
<tr>
<td>We can accomplish a lot by having a vast network of computers to use for accessing information and exchanging ideas</td>
<td></td>
</tr>
<tr>
<td>Packet switching can be used to send digitized data though computer networks</td>
<td></td>
</tr>
<tr>
<td>Hypertext can be used to allow rapid access to text data</td>
<td></td>
</tr>
<tr>
<td>We will prove that packet switching works over a WAN.</td>
<td></td>
</tr>
</tbody>
</table>
From Simple, But Significant Ideas Bigger Ones Grow 1970s to 1995

<table>
<thead>
<tr>
<th>1970</th>
<th>1995</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great efficiencies can be accomplished if we use The Internet and the World Wide Web to conduct business.</td>
<td></td>
</tr>
<tr>
<td>The World Wide Web is easier to use if we have a browser that To browser web pages, running in a graphical user interface context.</td>
<td></td>
</tr>
<tr>
<td>Computers connected via the Internet can be used more easily if hypertext links are enabled using HTML and URLs: it’s called World Wide Web</td>
<td></td>
</tr>
<tr>
<td>The ARPANET needs to convert to a standard protocol and be renamed to The Internet</td>
<td></td>
</tr>
<tr>
<td>We need a protocol for Efficient and Reliable transmission of Packets over a WAN: TCP/IP</td>
<td></td>
</tr>
<tr>
<td>Ideas from 1940s to 1969</td>
<td></td>
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</tbody>
</table>
The Creation of the Internet

- The creation of the Internet solved the following challenges:
  - Basically inventing digital networking as we know it
  - Survivability of an infrastructure to send / receive high-speed electronic messages
  - Reliability of computer messaging
Tribute to the Internet Pioneers

• The Internet we know and love today, would not exist without the hard work of a lot of bright people.
• The technologies and standards they created make today’s Internet and World Wide Web possible.
• They deserve recognition and our gratitude for changing the world with the Internet.
• In this presentation, we will identify and pay tribute to several of the people who made the Internet and the World Wide Web possible.
Internet Pioneers in this Presentation

<table>
<thead>
<tr>
<th>Vannevar Bush</th>
<th>Claude Shannon</th>
<th>J. C. R. Licklider</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paul Baran</td>
<td>Ted Nelson</td>
<td>Leonard Kleinrock</td>
</tr>
<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>
Vannevar Bush

- Established the U.S. military / university research partnership that became ARPANET
- Wrote first visionary description of the potential use for information technology, inspiring many of the Internet's creators.

- President Roosevelt appointed Bush to Chairman of the National Defense Research Committee in 1940 to help with World War II.
- In 1941, Bush was appointed Director of the newly created "Office of Scientific Research and Development", established to coordinate weapons development research. The organization employed more than 6000 scientists by the end of the war, and supervised development of the atom bomb.
- From 1946 to 1947, Bush served as chairman of the Joint Research and Development Board. Out of this effort would later come DARPA, which would later do the ARPANET Project.

Quote:
- "Consider a future device for individual use, which is a sort of mechanized private file and library. It needs a name, and to coin one at random, "memex" will do. A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory.
- It consists of a desk, and while it can presumably be operated from a distance, it is primarily the piece of furniture at which he works. On the top are slanting translucent screens, on which material can be projected for convenient reading. There is a keyboard, and sets of buttons and levers. Otherwise it looks like an ordinary desk.

- Vannevar Bush; *As We May Think*; Atlantic Monthly; July 1945

Source: Livinginternet.com
Claude Shannon

• **The Father of Modern Information Theory**

• Created idea that all information could be represented using 1s and 0s. Called these fundamental units BITS.

• Created concept data transmission in BITS per second.

• Published a “A Mathematical Theory of Communication” in 1948: Before Shannon, it was commonly believed that the only way of achieving arbitrarily small probability of error in a communication channel was to reduce the transmission rate to zero. All this changed in 1948 with the publication of A Mathematical Theory of Communication, where Shannon characterized a channel by a single parameter; the channel capacity, and showed that it was possible to transmit information at any rate below capacity with an arbitrarily small probability of error. His method of proof was to show the existence of a single good code by averaging over all possible codes. His paper established fundamental limits on the efficiency of communication over noisy channels, and presented the challenge of finding families of codes that achieve capacity.

• Won a Nobel prize for his master’s thesis in 1936, titled, “A Symbolic Analysis of Relay and Switching Circuits”, it provided mathematical techniques for building a network of switches and relays to realize a specific logical function, such as a combination lock.

J. C. R. Licklider

• Developed the idea of a universal network,
• Spread his vision throughout Information Processing Techniques Office (IPTO), and
• Inspired creation of the ARPANET. He also
• Developed concepts that led to the idea of Netizen.

Licklider also realized that interactive computers could provide more than a library function, and could provide great value as automated assistants. He captured his ideas in a seminal paper in 1960 called Man-Computer Symbiosis, in which he described a computer assistant that could answer questions, perform simulation modeling, graphically display results, and extrapolate solutions for new situations from past experience. Like Norbert Wiener, Licklider foresaw a close symbiotic relationship between computer and human, including sophisticated computerized interfaces with the brain.

• Quote:
• It seems reasonable to envision, for a time 10 or 15 years hence, a ‘thinking center’ that will incorporate the functions of present-day libraries together with anticipated advances in information storage and retrieval.
• The picture readily enlarges itself into a network of such centers, connected to one another by wide-band communication lines and to individual users by leased-wire services. In such a system, the speed of the computers would be balanced, and the cost of the gigantic memories and the sophisticated programs would be divided by the number of users.

Source: Livinginternet.com
Paul Baran

- Developed the field of *packet switching* networks
- Conducted research on Survivable Comm Network

In 1959, a young electrical engineer named Paul Baran joined RAND from Hughes Aircraft's systems group. The US Air Force had recently established one of the first wide area computer networks for the SAGE radar defence system, and had an increasing interest in survivable, wide area communications networks so they could reorganize and respond after a nuclear attack, diminishing the attractiveness of a first strike option by the Soviet Union.

Baran began an investigation into development of survivable communications networks, the results of which were first presented to the Air Force in the summer of 1961 as briefing B-265, then as paper P-2626, and then as a series of eleven comprehensive papers titled *On Distributed Communications* in 1964.

Baran's study describes a remarkably detailed architecture for a distributed, survivable, packet switched communications network. The network is designed to withstand almost any degree of destruction to individual components without loss of end-to-end communications. Since each computer could be connected to one or more other computers, it was assumed that any link of the network could fail at any time, and the network therefore had no central control or administration.

Baran's architecture was well designed to survive a nuclear conflict, and helped to convince the US Military that wide area digital computer networks were a promising technology. Baran also talked to Bob Taylor and J.C.R. Licklider at the IPTO about his work, since they were also working to build a wide area communications network. His 1964 series of papers then influenced Roberts and Kleinrock to adopt the technology for development of the ARPANET network a few years later, laying the groundwork that leads to its continued use today.

Baran has also received several awards, including the IEEE Alexander Graham Bell Medal, and the Marconi International Fellowship Award.

Source: Livinginternet.com
Leonard Kleinrock

- One of pioneers of digital network communications
- Helped build the early ARPANET
- Connected First Node on ARPANET


After completing his thesis in 1962, Kleinrock moved to UCLA, and later established the Network Measurement Center (NMC), led by himself and consisting of a group of graduate students working in the area of digital networks. In 1966, Roberts joined the IPTO with a mandate to develop the ARPANET, and used Kleinrock’s Communication Nets to help convince his colleagues that a wide area digital communication network was possible. In October, 1968, Roberts gave a contract to Kleinrock's NMC as the ideal group to perform ARPANET performance measurement and find areas for improvement.

On a historical day in early September, 1969, a team at Kleinrock’s NMC connected one of their SDS Sigma 7 computers to an Interface Message Processor, thereby becoming the first node on the ARPANET, and the first computer ever on the Internet.

As the ARPANET grew in the early 1970’s, Kleinrock's group stressed the system to work out the detailed design and performance issues involved with the world’s first packet switched network, including routing, loading, deadlocks, and latency. The UCLA Netwatch program now performs similar functions to Kleinrock’s Network Management Center from the ARPANET years.

Kleinrock has continued to be active in the research community, and has published more than 200 papers and authored six books. In August, 1989, he organized and chaired a symposium commemorating the 20th anniversary of the ARPANET, which later produced the document RFC 1121, titled "Act One -- The Poems".

Source: Dr. Kleinrock’s Homepage
Lawrence Roberts

- **ARPANET** program manager, and led the overall system design
- conducted research into computer networks at MIT Lincoln Laboratory
- Foundational Work in Time-Sharing Computers
  - In February, 1965, the director of the IPTO, Ivan Sutherland, gave a contract to Roberts to develop a computer network. In July, Roberts gave a contract to Thomas Marill, who had also been inspired by Licklider, to program the network. In October, 1965, the Lincoln Labs TX-2 computer talked to their SDC's Q32 computer in one of the world's first digital network communications.
  - In October, 1966, Roberts and Marill published a paper titled *Toward a Cooperative Network of Time-Shared Computers* at the Fall AFIPS Conference, documenting their networking experiments.
  - Also in 1966, DARPA head Charlie Hertzfeld promised IPTO Director Bob Taylor a million dollars to build a distributed communications network if he could get it organized. Taylor was greatly impressed by Lawrence Roberts work, and asked him to come on board to lead the effort. Roberts resisted at first, and then joined as ARPA IPTO Chief Scientist in December 1966 when Taylor brought pressure on him through Hertzfeld and his boss at the Lincoln Lab. Roberts then immediately started working on the system design for a wide area digital communications network that would come to be called the ARPANET.
Lawrence Roberts

- Roberts presented a paper called *Multiple Computer Networks and Intercomputer Communication* that summarized the ARPANET plan at the ACM Symposium on Operating System Principles at Gatlinburg, Tennessee, in October 1967. He then wrote a program plan called "Resource Sharing Computer Networks" to build a working implementation of the network. The project justified itself, in part, by arguing that different departments would be able to log into other computers and use their programs remotely, thereby saving the costs of buying or building programs themselves, and greatly expanding the capabilities available to each site on the network. He gave the report to Taylor on June 3, 1968, who approved it on June 21. The work was begun.
- Roberts also hired the developer of TCP/IP, Bob Kahn, who had worked on the Interface Message Processor at BBN.
- Roberts became Director of the IPTO when Taylor left in September, 1969. Roberts left the IPTO in October, 1973, to become CEO of Telenet, the first packet switching network carrier, which later standardized on the X.25 networking system originally used on the *EUnet*. Roberts later left Telenet when it was sold to GTE in 1979 and became the data division of Sprint.
- In 1982, Roberts was President and CEO of DHL. From 1983 to 1993, he was Chairman and CEO of NetExpress, Inc., an electronics company specializing in packetized facsimile and ATM equipment. From 1993 to 1998, he was President of networking company ATM Systems. In the late 1990's, Roberts was Chairman and CTO of Packetcom, specializing in advanced Internet routers with improved quality of service.
- Roberts has received numerous awards for his work, including the Secretary of Defense Meritorious Service Medal, the Harry Goode Memorial Award from the American Federation of Information Processing, the IEEE Computer Pioneer Award, the Interface Conference Award, the L.M. Ericsson prize for research in data communications in 1982, the IEEE Computer Society W. Wallace McDowell Award in 1992, and the ACM SIGCOMM communications award in 1998.

Source: Livinginternet.com
Steve Crocker

• Part of team which developed protocols for the Arpanet and laid the foundation for today’s Internet

• Organized the Network Working Group, forerunner of the modern Internet Engineering Task Force

• Steve Crocker is an Internet and computer security expert. Steve Crocker Associates, LLC is a consulting and R&D company specializing in current Internet and electronic commerce technologies. Executive DSL, LLC is an ISP specializing in the integration of Internet-based services for small and medium businesses.

• Dr. Crocker has been a program manager at Advanced Research Projects Agency (ARPA), a senior researcher at USC’s Information Sciences Institute, founder and director of the Computer Science Laboratory at the Aerospace Corporation and a vice president at Trusted Information Systems before joining CyberCash. Dr. Crocker served as the area director for security in the Internet Engineering Task Force for four years and as a member of the Internet Architecture Board for two years. Dr. Crocker holds a B.A. in mathematics and a Ph.D. in Computer Science from UCLA.

Source: www.epf.net
Jon Postel

- From Jon Postel's Bio:
- Jon Postel is the Director of ISI's Computer Networks Division. The division has 70 staff members working on about 10 projects, including the NSF sponsored Routing Arbiter, and DARPA sponsored projects in the areas of Active Networks, Middleware, Security, Distributed Systems, and High Speed Networking.
- He received his B.S. and M.S. in Engineering, and his Ph.D. in Computer Science from UCLA, in 1966, 1968, and 1974 respectively. Jon is a member of the ACM and the Internet Society (and currently serves on the Internet Society Board of Trustees).
- At UCLA he was involved in the beginnings of the ARPANET and the development of the Network Measurement Center.
- He has worked in the areas of computer communication protocols, especially at the operating system level and the application level.
- His current interests include multi-machine internetwork applications, multimedia conferencing and electronic mail, very large networks, and very high speed communications.
- Jon is also involved in several Internet infrastructure activities including the Internet Assigned Numbers Authority, the RFC Editor, the US Domain, and the Los Nettos network (a regional network for the greater Los Angeles area).
- Jon was regarded by many to be the ‘policeman of Internet Standards” for many years during the infancy of the Internet.
- Jon was honored by Dr. Vint Cerf in October 1998, shortly after his passing with the addition of RFC 2468.

Source: Livinginternet.com
Vinton Cerf

- Co-designer of the TCP/IP networking protocol.
- **Resources.** author of three *entertaining RFCs* and contributed to a fourth:
  - RFC 968; "Twas the Night Before Start-up"; December, 1985.
- Other online publications by Cerf are listed below:
  - How the Internet Came to Be.
  - A Brief History of the Internet and Related Networks.
  - Internet: Past, Present, and Future.

Source: Livinginternet.com
Robert Kahn

- Co-designer of the *TCP/IP* networking protocol.
- He set four goals for the TCP design:
  - **Network Connectivity.** Any network could connect to another network through a gateway.
  - **Distribution.** There would be no central network administration or control.
  - **Error Recovery.** Lost packets would be retransmitted.
  - **Black Box Design.** No internal changes would have to be made to a computer to connect it to the network.

Source: Livinginternet.com
Tim Berners-Lee

- **The inventor of HTML** and directs the W3 Consortium, an open forum of companies and organizations with the mission to realize the full potential of the Web.
- In 1989 invented the World Wide Web while working at CERN, the European Particle Physics Laboratory.
- Before coming to CERN, was a founding director of Image Computer Systems, and a principal engineer with Plessey Telecommunications.
Mark Andreesen

• Co-developer with Eric Bina of one of the earliest browsers, Mosaic
• Much more sophisticated graphically than other browsers of the time
• Designed to display HTML documents, but new formatting tags like "center" were included.
• Inclusion of the "image" tag which allowed to include images on web pages.
• Mosaic made it possible for images and text to appear on the same page.
• Mosaic also sported a graphical interface with clickable buttons that let users navigate easily and controls that let users scroll through text with ease.
• Another innovative feature was the hyper-link.
• Hyper-links allowed the user to simply click on a link to retrieve a document.

Source: www.ibiblio.org/pioneers
Internet Growth Trends
Internet Growth Trends

- 1977: 111 hosts on Internet
- 1981: 213 hosts
- 1983: 562 hosts
- 1984: 1,000 hosts
- 1986: 5,000 hosts
- 1987: 10,000 hosts
- 1989: 100,000 hosts
- 1992: 1,000,000 hosts
- 2001: 150 - 175 million hosts
- 2002: over 200 million hosts
- By 2010, about 80% of the planet will be on the Internet
No. of Participating Hosts
Oct. ‘90 - Apr. ‘98

Hobbes' Internet Timeline Copyright ©1998 Robert H Zakon
http://www.isoc.org/zakon/Internet/History/HIT.html

<table>
<thead>
<tr>
<th>DATE</th>
<th>HOSTS</th>
<th>DATE</th>
<th>HOSTS</th>
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<tr>
<td>1969</td>
<td>4</td>
<td>10/85</td>
<td>1,961</td>
</tr>
<tr>
<td>04/71</td>
<td>23</td>
<td>02/86</td>
<td>2,308</td>
</tr>
<tr>
<td>06/74</td>
<td>62</td>
<td>11/86</td>
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<td>03/77</td>
<td>111</td>
<td>12/87</td>
<td>28,174</td>
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<td>08/81</td>
<td>213</td>
<td>07/88</td>
<td>33,000</td>
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<td>05/82</td>
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<tr>
<td>08/83</td>
<td>562</td>
<td>07/89</td>
<td>130,000</td>
</tr>
<tr>
<td>10/84</td>
<td>1,024</td>
<td>10/89</td>
<td>159,000</td>
</tr>
</tbody>
</table>

New Survey
Old Survey
March 2001

Over 115 Million Hosts
(As of Jan. 2001)

Over 407 Million Users
(As of Nov. 2000)

218 of 246 Countries
(As of Jan. 2000)

> 31 Million Domain Names

About 100 TB of Data

Dr. Vint Cerf presents in Chicago
at the Drake Hotel on March 2001
The event was a fund-raiser for the ITRC
By September 2002
The Internet Reached Two
Important Milestones:

200,000,000 IP Hosts
840,000,000 Users

Netsizer.com - from Telcordia
The Internet was not known as “The Internet” until January 1984, at which time there were 1000 hosts that were all converted over to using TCP/IP.

Copyright 2002, William F. Slater, III, Chicago, IL, USA
The Internet Host Count in Realtime on September 1, 2002 - Over 204,000,000 IP Hosts!!!

Chart showing Internet Growth from Sept. 1, 2001 to Sept. 1, 2002.
Source Netsizer.com
Domain Name Registration
Jan. ‘89 - Jul. ‘97

April 2001: 31,000,000 Domain Names!!!
Statistics from the IITF Report
The Emerging Digital Economy *

- To get a market of 50 Million People Participating:
  - Radio took 38 years
  - TV took 13 years
  - Once it was open to the General Public, The Internet made to the 50 million person audience mark in just 4 years!!!

- http://www.ecommerce.gov/emerging.htm
  - Released on April 15, 1998

* Delivered to the President and the U.S. Public on April 15, 1998 by Bill Daley, Secretary of Commerce and Chairman of the Information Infrastructure Task Force
For More Information, Please Contact:

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  - isoc-chicago.org
  - 773-235-3080
The History of the Internet

http://www.uky.edu/Classes/MKT/390/slides/history.ppt
Three Major Players in Internet History
Early Innovations

The creation of the Internet is dependent on mankind’s earlier innovations

1836 - Telegraph by Cooke and Wheatstone
• Revolutionized human (tele)communications.
• Morse Code a series of dots and dashes used to communicate between humans. This is similar to how computers communicate via (binary 0/1) data today. Although it is much slower!!

1858-1866 - Transatlantic cable. Allowed direct instantaneous communication across the Atlantic. Today, cables connect all continents and are still a main hub of telecommunications.

1876 - Telephone. Alexander Graham Bell Exhibits.
• Telephones exchanges provide the backbone of Internet connections today.
• Modems provide Digital to Audio conversions to allow computers to connect over the telephone network.
1940’s to 1980’s - U.S. vs. Soviet Cold War

1957 - U.S.S.R. launches Sputnik. The US forms the Advanced Research Projects Agency (ARPA) within the Department of Defense (DoD) to build US skills in computer technology.

• The start of global telecommunications. Satellites play an important role in transmitting all sorts of data today.
ARPA Created

**1957** - In response, US forms the Advanced Research Projects Agency (ARPA) within the Department of Defense (DoD) to establish US lead in science and technology applicable to the military.

**1962** - Dr. J.C.R. Licklider was chosen to head ARPA's research in improving the military's use of computer technology.

- Licklider was a visionary who sought to make the government's use of computers more interactive.
- moved ARPA's contracts from the private sector to universities and laid the foundations for what would become the ARPANET.
Packet-Switching is Key

1962-1968 - Packet-switching (PS) networks developed

- The Internet relies on packets to transfer data.
- Data is split into tiny packets that may take different routes to a destination.
- The origin is military: for utmost security in transferring information of networks (no single outage point).
- More than one route available -- if one route goes down another may be followed.
- Networks can withstand large scale destruction (Nuclear attack - This was the time of the Cold War).
The Story of ARPANET - Team

1969 - ARPANET commissioned by DoD for research into networking. The Team included:

**Bob Taylor**, a psychoacoustician, was director of the computer research program at the Department of Defense's Advanced Research Projects Agency in 1966 when he hit upon the idea of lining computers together. He was awarded $1 Million to develop the network.

**Larry Roberts**, a pioneer in computer networking at MIT's Lincoln Laboratory. He designed the original four-node network, which was to be based on packet-switching, as opposed to circuit-switching.
The Story of ARPANET – the Nodes

1969 – Four nodes and a test

• First node at UCLA

soon after at:

• Stanford Research Institute (SRI)
• UCSB
• U of Utah
The Story of ARPANET – The IMPs

1969 – To connect these four computers – each with its own “language” – Wes Clark suggested to Larry Roberts that 4 small computers that spoke the same language be constructed and connected together.

• The small computers were called Information Message Processors (IMP) [Honeywell 516 mini computer with 12K of memory] developed by Bolt Beranek and Newman, Inc. (BBN)
The Birth of the Internet

The plan was unprecedented: Kleinrock, a pioneering computer science professor at UCLA, and his small group of graduate students hoped to log onto the Stanford computer and try to send it some data.

Steve Crocker developed ARPANET network protocol

Jon Postel developed Domain Name System, FTP, Telnet, and the Internet Protocol.

Mike Wingfield built the hardware interface between the UCLA computer and the first IMP

Vinton Cerf develop TCP/IP

Bill Naylor
They would start by typing "login," and seeing if the letters appeared on the far-off monitor.

Kleinrock: "We set up a telephone connection between us and the guys at SRI...,"

"We typed the L and we asked on the phone, "Do you see the L?"

"Yes, we see the L," came the response.

"We typed the O, and we asked, "Do you see the O."

"Yes, we see the O."

"Then we typed the G, and the system crashed"

Yet a revolution had begun"

Source: Sacramento Bee, May 1, 1996, p.D1
1971 - Ray Tomlinson of BBN invents email program to send messages across a distributed network. The original program was derived from two others:

- an intra-machine email program (SNDMSG) and an experimental file
- transfer program (CPYNET)
- 15 nodes (23 hosts) on ARPANET.

The first e-mail message??

qwertyuiop
The Birth of the Internet

1973 - Global Networking becomes a reality
• First international connections to the ARPANET: University College of London (England) and Royal Radar Establishment (Norway)

1974 - Packets become mode of transfer
• Transmission Control Program (TCP) specified. Packet network Intercommunication -- the basis of Internet Communication.
• Telenet, a commercial version of ARPANET, opened -- the first public packet data service.

1976 - Networking comes to many
• Queen Elizabeth sends out an e-mail.
The Birth of the Internet

1977 - E-mail takes off, Internet becomes a reality
• Number of hosts breaks 100.
• THEORYNET provides electronic mail to over 100 researchers in computer science (using a locally developed E-mail system and TELENET for access to server).

1979 - News Groups born
• Computer Science Department research computer network established in USA.
• USENET established using UUCP.
  – A collection of discussions groups, news groups.
  – 3 news groups established by the end of the year
  – Almost any topic now has a discussion group.
The Birth of the Internet

1979 - News Groups born

- Computer Science Department research computer network established in USA.
- USENET established using UUCP.
  - USENET still thrives today.
  - A collection of discussions groups, news groups.
  - 3 news groups established by the end of the year
  - Almost any topic now has a discussion group.
The Birth of the Internet

1982 - TCP/IP defines future communication • DCA and ARPA establishes the Transmission Control Protocol (TCP) and Internet Protocol (IP), as the protocol suite, commonly known as TCP/IP, for ARPANET.

- Leads to one of the first definitions of an Internet as a connected set of networks, specifically those using TCP/IP.

1983 - Internet gets larger

Name server developed.

- There is such a large number of nodes that it's hard to remember exact paths
- Use meaningful names instead.
The Birth of the Internet

1984 - Growth of Internet Continues
- Number of hosts breaks 1,000.
- Domain Name Server (DNS) introduced. Instead of 123.456.789.10 it is easier to remember something like www.myuniversity.mydept.mynetwork.mycountry
- (e.g. www.cs.cf.ac.uk).

1986 - Power of Internet Realized
- 5,000 Hosts. 241 News groups.
- NSFNET created when NSF establishes 5 super-computing centers to provide high-computing power for all -- This allows an explosion of connections, especially from universities.
The Birth of the Internet

1987 - Commercialization of Internet Born
• Number of hosts 28,000.
• UUNET is founded with Usenix funds to provide commercial UUCP and Usenet access.

1988
• Internet Relay Chat (IRC) developed

1989 - Large growth in Internet
• Number of hosts breaks 100,000
• First relays between a commercial electronic mail carrier and the Internet
The Birth of the Internet

1990 - Expansion of Internet continues

- 300,000 Hosts. 1,000 News groups

- ARPANET ceases to exist

- Archie released files can be searched and retrieved (FTP) by name.

- The World comes on-line (world.std.com), becoming the first commercial provider of Internet dial-up access.
The Birth of the Internet

1991 - Friendly User Interface to Internet established

- Gopher released by Paul Lindner and Mark P. McCahill from the U of Minnesota.
  - Text based, menu-driven interface to access internet resources.
  - No need to remember or even know complex computer command. User Friendly Interface (??).
  - Largely superseded by WWW, these days.
The Birth of the Internet

1992 - Multimedia changes the face of the Internet

- Number of hosts breaks 1 Million. News groups 4,000
- The term "Surfing the Internet" is coined by Jean Armour Polly.
The Birth of the Internet

1993 - The WWW Revolution truly begins

- Number of Hosts 2 Million. 600 WWW sites.
- The Mosaic Web browser is released (by a group of 10 students from U of I at Champaign-Urbana) on the Net, gaining 2 million and fueling a 341,634% annual growth rate for Web traffic.
The Birth of the Internet

1993 - The WWW Revolution truly begins

- The White House opens its Web page and the President gets an e-mail address.
- Business and Media really take notice of the Internet.
- Mosaic takes the Internet by storm.
  - User Friendly Graphical Front End to the World Wide Web.
  - Develops into Netscape -- most popular WWW browser to date.
## The Birth of the Internet

### The Stats Map of Net History

<table>
<thead>
<tr>
<th>Date</th>
<th>Hosts</th>
<th>Domains*</th>
<th>WebSites</th>
<th>WHR(%)***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan-98</td>
<td>29,670,000</td>
<td>2,500,000**</td>
<td>2,450,000**</td>
<td>8.3</td>
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<tr>
<td>Jul-97</td>
<td>19,540,000</td>
<td>1,301,000</td>
<td>1,200,000</td>
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<td>Jul-96</td>
<td>12,881,000</td>
<td>488,000</td>
<td>300,000</td>
<td>2.3</td>
</tr>
<tr>
<td>Jul-95</td>
<td>6,642,000</td>
<td>120,000</td>
<td>25000</td>
<td>0.4</td>
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<tr>
<td>Jul-94</td>
<td>3,212,000</td>
<td>46,000</td>
<td>3,000</td>
<td>0.1</td>
</tr>
<tr>
<td>Jul-93</td>
<td>1,776,000</td>
<td>26,000</td>
<td>150</td>
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<td>992,000</td>
<td>16,300</td>
<td>50</td>
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<td>Jul-81</td>
<td>210</td>
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<td>--</td>
</tr>
<tr>
<td>1969</td>
<td>4</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
INTERNET STATISTICS

- There are 3.26 billion internet users as at December 2015.
- Facebook has 1.55 billion active users.
- China has the highest number of internet users (640 million).
- 2.9 billion Google searches are made every day.
- Digital interactions influenced retail sales to the tune of $2.2 trillion in 2015.
- 2.7 million blog posts are published every day.

48.4% of internet users are from Asia.

Bermuda has the highest internet penetration (97.75% of people in Bermuda use the internet).
**DOMAIN NAME STATISTICS**

- The `.COM` TLD is the world's number one domain name extension.
- There are over **123.78 million** registered `.COM` domain names.
- The `.COM` TLD accounts for **50%** of all registered domain names.
- There are total of **1096 TLDs** (November 2015).
- The most expensive domain name ever sold is insurance.com, for **$35.6 million** in 2010.

---

**Internet Traffic**

- 44% of internet traffic comes from robots.
- 56% of internet traffic is human.
The first website was published in August 1991 by Tim Berners-Lee. WordPress is responsible for 76.5 million blogs. There are over 966 million websites in the world today. WordPress is the most popular CMS. The highest number of websites to ever exist was 1 billion (the record was achieved in September 2014).
E-Commerce & Conversion Statistics

7% A one second delay in site loading time will lead to loss in conversion.

1 Billion people have bought products online.

40% Of people will abandon your website if it takes longer than 3 seconds to load.

The U.S. E-Commerce economy is worth $349 billion.

China's E-Commerce economy is worth $562.66 billion.

51% Of U.S. online shoppers abandon a purchase because of slow websites.

Slow loading sites cost the U.S. E-Commerce market more than $500 billion annually.

40% Of shoppers consult 3 or more channels before making a purchase.

97% Of users abandon mobile shopping carts, compared to around 70-75% for desktop users.

Increasing your website speed from 8 to 2 seconds can increase your conversion rate by 74%.

8/10 consumers will shop online if free shipping is available.

Internet visits from desktop lead to more sales than visits from other devices.
Mobile Internet
Statistics & Facts

48% of mobile users start searching on
search engines

Google now uses mobile compatibility as
a ranking factor

4/5 consumers use a smart-phoneto shop

70% of mobile searches result in an
online action within an hour of
the search being conducted

50% of mobile users will abandon
a web page if it takes
more than
10 seconds
to load and
60%
won’t return to the site

There are more mobile users
(52.7%)
worldwide than
desktop users

75.1% of U.S. internet users access the
internet through a
mobile device
Number of internet users by world region, 1990 to 2015

Data source: World Bank: Science and Technology

https://ourworldindata.org/internet/
Mobile cellular subscriptions by country, 1980 to 2013
Subscriptions per 100 people.

Data source: World Bank: Science and Technology

https://ourworldindata.org/internet/
Broadband penetration by country, 1998 to 2014

Data source: World Bank: Science and Technology

https://ourworldindata.org/internet/
Internet user demographics in the United States – Pew Research Center


https://ourworldindata.org/internet/
The Role of DARPA

Ed Lazowska
History of Computing
Autumn 2006
Overview of “Tire Tracks Diagram”

- Shows 19 $1B (or larger) sub-sectors of IT
- Shows university research (federal funding), industry research (industry or federal funding), product introduction, $1B market
- Shows flows within sub-sectors, and between sub-sectors
- Shows a subset of the contributors, for illustrative purposes
Key concepts illustrated

- Every major $1B IT sub-sector bears the stamp of federal research funding
- Every sub-sector shows a rich interplay between university and industry
- It’s not a “pipeline” – there’s lots of “back-and-forth”
- It typically takes 10-15 years from idea to $1B industry
- There are many research interactions across sub-fields
Key concepts not directly illustrated

- Unanticipated results are often as important as anticipated results
- It’s hard to predict the next “big hit”
- Research puts ideas in the storehouse for later use
- University research trains people
- University and industry research tend to be complementary
- Visionary and flexible program managers have played a critical role
Alfred Lee Loomis

- Wall Street
- Tuxedo Park
- MIT Rad Lab
Vannevar Bush

- Roosevelt’s WW II science advisor; Director, OSRD
- “Pipeline model”; “one tent”
- Science: The Endless Frontier, 1945
- “One tent” fell by the wayside
Eisenhower, Licklider

- ARPA established in 1957
- J.C.R. Licklider hired as first head of IPTO, 1962
(D)ARPA’s mission

“DARPA’s mission is to maintain the technological superiority of the U.S. military and prevent technological surprise from harming our national security by sponsoring revolutionary, high-payoff research that bridges the gap between fundamental discoveries and their military use.”
(D)ARPA’s mission

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■ **Stealth Fighter**
Early efforts by DARPA led to the development of the Air Force F-117 tactical fighter that was so successful in the Desert Storm operation, flying 1,271 sorties without a single aircraft loss, penetrating air defenses, and delivering 2,000 tons of ordnance to account for some 40% of all targets with an 80%-85% hit rate.

■ **Stealth Bomber**
DARPA's support to the design and fabrication of the TACIT BLUE low-observable stealth aircraft contributed directly to the development of the B-2 Stealth Bomber. Most notably, the TACIT BLUE was the first aircraft to demonstrate a low radar cross section using curved surfaces, along with a low probability of intercept radar and data link.
Uncooled Infrared (IR) Sensors
The U.S. military has "owned the night" because of generations of cryogenically cooled IR sensors. These sensors were a major reason for the ground victory in Desert Storm. Unfortunately, the high cost of cooled sensors has precluded wide distribution to combat troops for human-portable applications. The Low Cost, Uncooled Sensor Program (LOCUSP) at DARPA initially developed, fabricated, and demonstrated this new technology. The uncooled IR technology, furthered under DARPA's dual-use initiatives, is a reality and has been accepted into the Army as a prototype and awaits production for fielding.

Head-Mounted Displays
This program enabled soldiers to view information from a head-mounted sensor and also from a wearable computer. It developed a capability that never before existed and was not expected to exist until well into the twenty-first century.

DARPA awarded separate development contracts for miniature displays and an integrated head-mounted display system. They were mated under a technology development and integration effort. DARPA's head-mounted subsystem is being integrated into the Army's Land Warrior Program and the Generation II soldier. Both of these Army programs plan to upgrade their systems with DARPA-developed display technologies.
**Unmanned Undersea Vehicle**

There are a number of Navy missions in the littoral that cannot be performed safely by a full-sized, manned platform. They include mine location and avoidance as well as remote surveillance. In 1988 a joint DARPA/Navy Unmanned Undersea Vehicle (UUV) Program was initiated with the goal of demonstrating that UUVs could meet specific Navy mission requirements.

The Navy initially pursued a submarine launched UUV that would either guide the submarine through an area that might be mined or search an area for mines. As a result of the end of the Cold War, the Navy revised the program with the objective of developing a tethered shallow water mine reconnaissance vehicle for littoral warfare. A system will be demonstrated in the Joint Mine Countermeasures Advanced Concept Technology Demonstration (ACTD) in 1998.
**Phased Array Radars**

DARPA pioneered the construction of large, ground-based, phased array radars, such as the FPS-85, with a program called Electronically Steered Array Radar (ESAR). The FPS-85 phased array radar had a range of several thousand miles and could detect, track, identify, and catalog earth-orbiting objects and ballistic missiles. The FPS-85 quickly became part of the Air Force SPACETRACK system and is operational today.

**Phased Array Radars.**
- **Endurance Unmanned Air Vehicles**

DARPA developed the first endurance unmanned aerial vehicle (UAV), Amber. DARPA-developed technologies from that and related programs led to the Gnat 750 UAV, the Air Force-operated Tier 2 Predator UAV that was used in Bosnia. Operating at altitudes of up to 25,000 feet for periods exceeding forty hours, the Predator operated successfully as an element of Exercise Roving Sands in early 1995 and has been deployed to the Bosnia crisis to support UN and NATO operations. Originally a Navy-Army joint effort, the Predator UAV was transitioned to the Air Force in 1995 for operation and maintenance.
Cermet Materials for Armor

The Lanxide material discovered by M. Newkirk at Lanxide Corporation has resulted in hundreds of patents. Variations have been used successfully as appliqué armor for the Marine Corps’ Light Armored Vehicles (LAV) in Operation Desert Storm (particularly for roof protection from artillery). This insertion was funded by the DARPA ceramicinsertion program. Seventy-five LAVs were up-armored. Products were adopted in 1993 for the M-9 Armored Combat Earthmover (ACE) and for several transport aircraft, such as the C-17.
The Internet

- **1966**: First experiments in digital packet switched technology

- **1968**: ARPA issues RFQ for IMPs
  - AT&T says it’ll never work, and even if it does, no one will care

- **1969**: ARPANET inaugurated with 4 hosts
  - Len Kleinrock’s student/programmer Charley Kline attempts remote login from UCLA SDS Sigma 7 to SRI SDS 940
  - System crashed partway through - thus, the first message on the Internet was “lo”
29 Oct 69
1:00
LOADED DID PROGRAM CSK
FOR BEN BARKER
BRX

22:30
Talked to SRF Host to Host

CSLE
Left imp. program (CSLE running after sending a host dead message to imp.)
1975: ARPANET has 100 hosts

1977: Crufty internetworking demonstration

- 4-network demonstration of ARPANET, SATNET, Ethernet, and PRnet - from a truck on 101 to England

1980: Design of TCP/IP completed

1983: Conversion to TCP/IP completed

- Routers allowed full internetworking - “network of networks”
- Roughly 500 hosts
**1988: ARPANET becomes NSFNET**
- Regional networks established
- Backbone speed 56kbps
- Roughly 100,000 hosts and 200 networks

**1989: CNRI interconnects MCImail to the Internet**
- Wise policy choice

**1990: Backbone speed increased to 1.5Mbps by IBM and MCI**
- Roughly 250,000 hosts and 1,500 networks
- Note: There still was “a backbone”!
1992: NCSA Mosaic stimulates explosive growth of WWW

1995: Full commercialization, at 45Mbps
   6,000,000 hosts, 50,000 networks

2005: 400,000,000 hosts; GENI initiative conceived
(D)ARPA I(P)TO

- J.C.R. Licklider, 1962-64
- Ivan Sutherland, 1964-65
- Bob Taylor, 1965-69
- Larry Roberts, 1969-73
- Al Blue (acting), 1973-74
- J.C.R. Licklider, 1974-75
- Dave Russell, 1975-79
- Bob Kahn, 1979-85
- Saul Amarel, 1985-87
- Jack Schwartz, 1987-89
- Barry Boehm, 1989-91
- Steve Squires, 1991-93
- John Toole (acting), 1993-94
- Howard Frank, 1994-97
- David Tennenhouse, 1997-99
- Shankar Sastry, 1999-01
- Kathy McDonald (acting), 2001-02
- Ron Brachman, 2002-05
- Charlie Holland, 2005-present
IPTO under Bob Kahn, 1979-85

- **VLSI program**
  - Mead-Conway methodology
  - MOSIS (Metal Oxide Silicon Implementation Service)
- **Berkeley Unix**
  - Needed Unix with virtual memory for the VLSI program (big designs) and the Image Understanding program (big images)
  - Also a Trojan horse for TCP/IP
  - And a common platform for much systems and application research
**SUN workstation**
- Baskett said no existing workstations could adequately handle VLSI designs (Bechtolsheim’s frame buffer approach was unique)
- Kahn insisted that it run Berkeley Unix

**Clear byproducts**
- Sun
- SGI
- RISC (MIPS, SPARC)
- TCP/IP adoption
- Internet routers (Cisco, 3com)
DARPA is a mission agency

“DARPA’s mission is to maintain the technological superiority of the U.S. military and prevent technological surprise from harming our national security ...”

Yes, DARPA has sponsored the vast majority of the groundbreaking research in speech and natural language ...
Phraselator

Phrase Translation Device for Military Use
- User speaks a phrase
- Automatic Speech Recognizer matches it to prerecorded translation
- Translation played through speaker
- Possible due to decades of ASR and systems research

Impact
Deployed in Operation Enduring Freedom and Iraqi Freedom
- Facilitated time-critical information exchange when interpreters not available
- Accepted by broad set of users
- Interaction with civilians – information on UXOs and weapons caches

Status
- Continued use in Iraq and Afghanistan
- Joint Forces Command fielding 800+ units
- SOCOM fielding 400 units
- Clear need for 2-way voice machine translation (VMT)
**TIDES+EARS: Automated processing of Arabic text & audio**

**Impact**
- CENTCOM using automated processing to pull intelligence from Arabic text and audio
- English-only operators can now form a picture in their mind of what is being discussed in Arabic source material
- 100’s of documents from dozens of sources translated daily; 5-10 sent to NVTC for human translation
- Technology first used by US Forces Korea

**Status**
- Automatic speech recognition of English improved dramatically from 1984 to 1993. Now, equally dramatic improvement for Arabic ASR through EARS
- Text and audio processing of Arabic now possible end-to-end. Two deployment units to CENTCOM in 2004 for information exploitation from Arabic open source material

---

**Automated translation and classification of foreign language text and audio**

- **TIDES**: Translation – foreign language text to English text, including document classification
- **EARS**: Transcription – converts Arabic and Chinese speech to text
- **TIDES and EARS integration**: Statistical learning – robust foreign language processing to extract intelligence from open sources.
DARPA’s traditional “style”

- Small and flexible
- Flat organization
- Autonomy and freedom from bureaucratic impediments
- World-class technical staff
- Teams and networks
- Hiring continuity and change
- Project-based assignments organized around a challenge model
DARPA’s traditional “style”

- Outsourced support personnel
- Outstanding program managers
- Acceptance of failure
- Orientation to revolutionary breakthroughs in a connected approach
- Mix of connected collaborators
Ethics in Computer Networks

Focus on Networks and Networking Professionals

- Ethical responsibilities and legal liabilities of network security professionals

Ethical, Privacy, and Security Issues in the Online Social Network Ecosystems

- Prof. Joseph Kizza
What are Some Ethical Issues?

- Should you read the private e-mail of your network users just because you can?
- Is it OK to monitor the Web sites visited by your network users?
- Is it OK to place key loggers on machines on the network to capture everything the user types?
- Is it OK to read the documents and look at the graphics files that are stored on users' computers or in their directories on the file server?

Debra Littlejohn Shinder, MCSE, MVP

http://www.computerworld.com/article/2557944/security0/ethical-issues-for-it-security-professionals.html
What can these issues cause?

- What if your perusal of random documents reveals company trade secrets?
- What if you later leave the company and go to work for a competitor?
- Is it wrong to use that knowledge in your new job?
- Would it be "more wrong" if you printed out those documents and took them with you, than if you just relied on your memory?
- What if the documents you read showed that the company was violating government regulations or laws?
- Do you have a moral obligation to turn them in, or are you ethically bound to respect your employer's privacy?
- Would it make a difference if you signed a nondisclosure agreement when you accepted the job?
A Scenario

What if a client asks you to save money by cutting out some of the security measures that you recommended, yet your analysis of the client's security needs shows that sensitive information will be at risk if you do so?

You try to explain this to the client, but he/she is adamant.

- Should you go ahead and configure the network in a less secure manner?
- Should you "eat" the cost and install the extra security measures at no cost to the client?
- Should you refuse to do the job?
- Would it make a difference if the client's business were in a regulated industry, and implementing the lower security standards would constitute a violation of the Health Insurance Portability and Accountability Act, the Graham-Leach-Bliley Act, Sarbanes-Oxley or other laws?
Ethical responsibilities and legal liabilities of network security professionals

- Interesting Article from Lawyer’s Perspective
  - Potential Ethical or Legal Problems For Keeping Network Vulnerability Secrets
  - The Ineluctable Consequences of Keeping Secrets about Security
  - Counting on Criminal Prosecutions to Police the Infobahn is Unrealistic
  - There is Nothing Ethically Wrong with the Insecure Design of the Internet, Because Nothing Ethical was Ever Intended by its Designers
  - The Better Technology Gets the More Tort Lawyers Like It
  - If We Can’t Kill All the Lawyers, Can Web Magic Make Users Waive Liability?
  - Will Awareness of Potential Legal Liabilities and Ethical Responsibilities Help Increase Security Precautions?
  - Distinguishing the Practice of Law as well as the Art and Science of Computer Network Security from Phrenology (mind/knowledge)

- Available on Uconn Library Online
  - Fred Chris Smith, of Counsel, Rose, Kohl & Davenport, Ltd. Santa Fe, NM

http://ieeexplore.ieee.org/document/646196/?reload=true&arnumber=646196
Module 13: Ethical, Privacy, and Security Issues in the Online Social Network Ecosystems

- Social Networks
- Online Social Networks (OSNs)
- Ethical and Privacy Issues in Online Social Networks
- Security and Crimes in Online Social Networks
- Proven Security Protocols and Best Practices in Online Social Networks

http://www.utc.edu/faculty/joseph-kizza/docs/socialandethicalissues/notes/chapter13.ppt
Online Crimes

- An *online crime* is a crime like any other crime, except it involves a connected computing system either as an object of a crime, an instrument used to commit a crime or a repository of evidence related to a crime.

- The International Convention of Cyber Crimes and the European Convention on Cyber Crimes both list the following crimes as online crime [1]:
  - Unlawful access to information
  - Illegal interception of information
  - Unlawful use of telecommunication equipment.
  - Forgery with use of computer measures
  - Intrusions of the Public Switched and Packet Network
  - Network integrity violations
  - Privacy violations
  - Industrial espionage
  - Pirated computer software
  - Fraud using a computing system
  - Internet/email abuse
  - Using computers or computer technology to commit murder, terrorism, pornography, and hacking.
Ways to Perpetuate Online Crimes

- System penetration - a process of gaining unauthorized access to a protected system’s resources, the system may be automated or not.

- Distributed Denial of Service (DDoS) - an interruption of service of the target system – when it is made either unavailable to users through disabling or destruction of it.

- Category include:
  - IP-spoofing
  - SYN-Flooding
  - Smurf attack
  - Buffer Overflow
  - Ping of Death
  - Land.c attack
  - Teardrop.c
  - Sequence Number Sniffing
Defense Against Online Crimes

- Prevention – one of the oldest and probably the best defence mechanism against online crimes. Must include the following:
  - A security policy
  - Risk management
  - Vulnerability assessment
  - Use of strong cryptographic algorithms
  - Penetration testing
  - Regular audits
  - Use of proven security protocols
  - Legislation
  - Self-regulation
  - Mass education
Proven Security Protocols and Best Practices

- There are hundreds of security protocols and best practices in use today
- The problem for security professional is to find the best
- Major categories are:
Authentication - a process of validating the identity of someone or something.

- uses information provided to the authenticator to determine whether someone or something is in fact who or what it is declared to be.
- requires one to present credentials or items of value to the authenticating agent in order to prove the claim of who one really is.
- items of value or credential are based on: something you know, something you have, or something you are:

  - **Something you know**: may be something you mentally possess like a password, a secret word known by the user and the authenticator. This technique of authentication is cheap but has weaknesses like memory lapses.
- **Something you have:** may be any form of issued or acquired self identification such as SecurID, Activcard, or any other forms of cards and tags. This authentication technique is slightly safer.

- **Something you are:** These are individual physical characteristic such as voice, fingerprint, iris pattern and other biometrics. Biometric authentication as we are going to see in Chapter 14 are the safest form of authentication.

- **Authentication methods** include:
  - password
  - public-key
  - anonymous
  - certificate-based
Access Control - a process of determining how access to the system’s potential resources can be provided to each of the system users.

- Several control techniques and technologies have been developed to deal with this problem; they include: Access Control Matrix, Capability Tables, Access Control Lists, Role-Based Access Control, Rule-Based Access Control, Restricted Interfaces, Content-Dependent Access Control and biometrics.

Legislation - process of enacting laws intended to curb the growth of these crimes.

- Sometimes enforceable laws can be productive.

Self-regulation - individuals finding ways to regulate objectionable material from reaching the children. This has become the cornerstone of efforts to stop the growing rate of online crimes.
Detection - mechanisms for preventing online crimes through 24-hour monitoring systems that continuously capture, analyze, and report on the daily happenings in and around the network.

Recovery - a process that consists of two sub processes:

- Analysis involving taking as much data as possible gathered during the last intrusion and analysing it for patterns that can be used in future for a response, for detection in future, and for prevention.

- Recovery requiring the use of all available resources to mitigate the problem in progress, recover whatever can be recovered and build new data in place of or to replace the destroyed data.
Networking Steve’s Used

- High school 1976
  - NONE
- Boston College 1976-1980
  - NONE
  - Phone Modem
- Ohio State 1982-1987 (1 year in Columbus)
  - Unix-to-Unix Copy Program - UUCP – Email
  - PCL Network (Parallel Communication Link)
  - DEC shipped a paper tape machine to install software
- Naval Postgraduate School 1983-1987
  - PCL Network (Parallel Communication Link)
  - 1st use of Ethernet but no broadcast capability
- UConn 1987-present
  - Faster Phone Modem (through 1990s)
  - Ethernet but no broadcast capabilities
UUCP
UUCP Messages – Bang Paths

- A list of host names to show a path for the message
- Separated by !
- Represents all of the network hops
- rt!foo!bar!swim!moria!janet
- midearth!shire!bilbo!jsmith
- utzoo!decvax!harpo!eagle!mhtsa!ihnss!ihuxp!grg