History Of The Internet

The events leading to the development of the Internet as well as major milestones since it's creation.

James Tam

World War II

- This is a (greatly) simplified and condensed version.[1]
- Many countries were involved (thus the name "World War").
- But there were two sides: the "Allies" and the "Axis"
- The Axis:
  - Germany
  - Japan
  - Italy
  - Several others
- The Allies:
  - U.S.A.
  - U.S.S.R.
  - Great Britain
  - France
  - Many, many other countries

•One (of many) additional source of information about the end of WWII, formation of NATO and NATO today http://www.nato.int/cps/en/natolive/opinions_20526.htm?selectedLocale=en

James Tam

World War II (2)

- It ended with the utter defeat of the Axis (the military of German and Japan were largely disarmed, Germany was partitioned into 'West Germany' and 'East Germany').
- West Germany: administered by the allies of the West e.g., USA and some Western European nations.
- East Germany (and several Eastern European countries): were administered by the USSR.
- Eventually (quickly?) some of the former allies were lined up in opposing alliances:
  - NATO: Canada, France, Italy, Spain, Turkey, USA, West Germany…
  - Warsaw pact: Albania, Bulgaria, Czechoslovakia, GDR (East Germany), Hungary, Poland, Romania, USSR.

James Tam

Need For Research

- As indicated in many previous sections the military recognized the benefits of research.
  - E.g., calculating trajectories of long range weapons such as artillery.
- To some extent the seeds of the Internet came out of World War II.[1]
  - President Roosevelt (before the US entry into WWII): believed that a technological edge (via airpower) was an alternate to fielding a large army.
  - 1944: the president wanted to support research so it could continue at it's wartime levels even after the war.
  - Vannevar Bush (chief scientific advisor to the government) recommended:
    - A general principle of the open sharing of knowledge rather than restriction.
    - Government support (but not control) of research.

James Tam

1 "A History of the Internet and the Digital Future" (Johnny Ryan, Reaktion Books)

Early Forms Of Networks

- SAGE (Semi Automatic Ground Environment) radar system (1950s)
  - Used for North American air defense.
  - Computers from different sites would communicate via modem.
- SABRE airline reservation system (1960s):
  - Two IBM 7090 mainframes were connected.
- But unlike the Internet these networks consisted of a single network.

James Tam

Origins Of The Internet

- What was happening in the 1950s

The Cold War

Image Credit: Microsoft

James Tam

The Cold War And The Space Race

- At the same time that each side (USSR-USA) was trying to be dominant on the ground they also wanted to be dominant in space.
  - Both sides tried to be the first to send a satellite into space.
- In the 1950s it appeared that the USSR had a technological edge:
  - Americans in 1957: A sophisticated three stage rocket was planned as the first human-made vehicle to be spent into space.
  - The USSR in 1957: surprised the world by launching Sputnik I (first artificial satellite).

http://astroprofspage.com

The Cold War And The Space Race (2)

- The launch of Sputnik helped motivate the creation of ARPA (Advanced Research Projects Agency) in the US.
- Later in 1957 the USSR launched another satellite carrying the dog Laika "bark/barker" (on a one way trip into space…).

Image Credit: Alexander Chernov/ Virtual Space Museum/ NASA

The Cold War And The Space Race (3)

- These events shook the US image as a technological super power (who had a technological lead in the Cold War).
  - It was believed that if the soviets could launch artificial satellites into space they could launch nuclear armed missiles at North America.
  - It was believed that the math and science requirements would have to be revamped in high school (so the Americans could out think their Soviet counterparts).
  - "…for your own sake and for the sake of the nation do your homework." (apparently a quote from the Harvard president James Bryan Conant).[1]
- To close the perceived technological gap president Dwight Eisenhower brought together the best technological minds and ARPA (Advanced Research Projects Agency), an arm of the department of defense, was created.[2]

1 "The Ancient History of the Internet" (Edwin Diamond , Stephen Bates): American Heritage Pct 95: Vol. 46, Issue 6

2 "On the Way to the Web" (Michael A. Banks)

ARPA

- APRA was a branch of the ministry of defense.
- The focus was on:
  - Getting different types of computers communicating
- It funded research at several universities across the US.
- Size and mandate of ARPA:
  - Very small: no physical labs
  - It issued research and development contracts to other organizations.
- 1962: ARPA's (then) director, Jack Ruina (focus on ballistic missile defense, nuclear test detonation) recruited JCR Licklider to work on "command and control, and behavioral sciences"

ARPA (2)

- Licklider's influence on ARPA:
  - 'User-friendliness': With a focus on 'usability' he saw the need for all ARPA research centers to agree upon the development language and/or develop common conventions.
  - Beginnings of the Internet ('Networking/connectivity'): Also collaboration between researchers was emphasized (this was not the norm).

ARPA (3)

- Bob Taylor (successor to Licklider's successor)[1]
  - Focus on efficiency: When he took over ARPA 3 separate and incompatible networks to communicate with 3 different research centers that worked with ARPA.

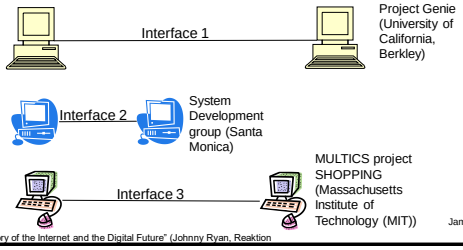


Image credits: Microsoft

1 "A History of the Internet and the Digital Future" (Johnny Ryan, Reaktion

ARPA (4)

- (Perhaps to address the efficiency issues): Proposed that ARPA begin work on a significant networking project (a significant push to the eventual creation of the Internet).
- The proposed network was eventually known as the ARPANET.
- The other leaders (at ARPA funded research centers) weren't enthusiastic about the networking project (it was an unknown entity and at the time few could perceive its benefits).
- Wesley Clarke (one of the founding fathers of the microcomputer) placated the researchers by stating that ARPA would pay for a small intermediary computer to be installed at each research center that would act as an intermediary between the computer used by the facility and the network (reduce load of the facility computer)

ARPA (5)

- (ARPA's method of motivating research groups to support work on developing a network continued)
  - Facility computer = Host
  - Intermediary computer = IMP (Interface Message Processor)
  - Prior to this suggestion the idea was to have a central computer control the ARPANET (a significant difference from how the Internet turned out).
- The work at ARPA was influenced by the work of other researchers:
  - Paul Baran's 'nuke proof' network to be developed at RAND.
  - The ARPANET was to be a robust connection (which along with other factors may have lead to the belief that the Internet was developed to withstand a nuclear war).
  - He was also influenced by Leonard Kleinrock (who wrote his Ph.D. thesis on the principles of a packet switched network)
  - Work at NPL (National Physical Laboratory: the term 'packet' was adapted from their work)

ARPA (6)

- **The major focus of the ARPANET**: was computer resource sharing and packet switched communications (although the term wasn't used at the time).[1,2]
  - This is in opposition to the belief that the motivation for developing the Internet was to have a 'nuke proof' network. (could function should nuclear war occur).
- Computer Resource sharing:

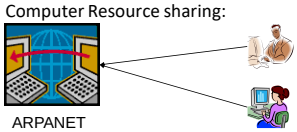


Image credits: Microsoft

1 "The Unknown History of the Internet" (Andreu Veà: Telecommunications Conference (HISTELCON), 2010 pp. 3 – 5)

2 "A brief history of the Internet" (Barry M. Leiner, Vinton G. cerf, David D. Clark, Robert E. Kahn, Leonard Kleinrock, Daniel C. Lynch, Jon Postel, Larry G. Roberts, Stephen Wolff, http://www.isoc.org/oti/articles/0597/leiner.html (last accessed July 2011).

ARPA (7)

- Packet switched network:
  - Message broken into parts (packets).
  - Packets from a single message might take different paths to reach the same destination.
  - Each packet is given enough information so it can reach it's destination and be re-assembled with other packets back into the original data.
  - If packets were missing then the packets could be resent.
  - Slower than telephone networks but more robust.

Origins Of Packet Switching

- Leonard Kleinrock (MIT) developed a theory behind a packet switched network. He published a paper on that theory in 1961 and a book in 1964[1, 2]
- Independently Paul Baran (RAND) developed similar principles for a voice network that would survive a nuclear strike (this research is often confused with the work done through ARPA).[1]
- Licklider (while at MIT) had introduced the concept he called the "Galactic Network (1962)"[1, 2]

1 "On the Way to the Web" (Michael A. Banks, Wiley)

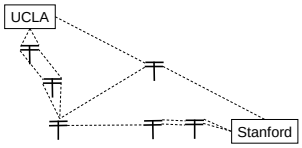
2 "A brief history of the Internet" (Barry M. Leiner, Vinton G. cerf, David D. Clark, Robert E. Kahn, Leonard Kleinrock, Daniel C. Lynch, Jon Postel, Larry G. Roberts, Stephen Wolff, http://www.isoc.org/oti/articles/0597/leiner.html (last accessed July 2011).

Origins Of Packet Switching (2)

- Donald Davies & Roger Scantelbury (NPL: UK) presented a paper on a packet network concept.
  - As mentioned the term 'packet' was adopted from the work at the NPL[2]

Connecting The Nodes

- The first host location chosen was UCLA
  - Due to Kleinrock's early development of packet switching theory his Network Measurement Centre at UCLA was selected to be first.
- The second host was located at Stanford
  - Douglas Engelbart's lab SRI (Stanford Research Institute)
- At the end of, 1969 the hosts were connected and information was transmitted between them (birth of the Internet)



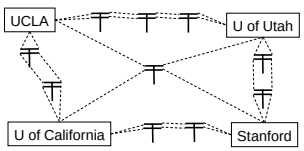
The First Data Sent On The Internet[1]

- Originally the message 'login' was to be transmitted.
- But the transmission stopped (i.e., it "died" after the first two characters.
  - …and thus 'LO' the Internet was born!

1 "On the Way to the Web" (Michael A. Banks, Wiley)

ARPANET Growth

- Later additional hosts were added to the network (end of 1969) from:
  - The University of California (Santa Barbara)
  - The University of Utah



The UCLA Lab[1]

- As mentioned it was headed by Leonard Kleinrock.
- His graduate students included:
  - Mike Wingfield (hardware engineer)
  - Steve Crocker and Vinton Cerf (who were to establish and refine the network communication protocols).
  - The Internet:
    - A big network (network of networks)
    - It's built on the protocols (makes the connections possible)

1 "On the Way to the Web" (Michael A. Banks, Wiley)

The UCLA Lab (2)

- Essentially this key research group consisted mostly of students and their (Prof) supervisors with no official charter.
  - "Most of us were graduate students, and we expected that a professional crew would show up eventually to take over…" [1] [JT: there were no seasoned veterans in the creation of the Internet protocols, this was it].
- Six graduate students were left to develop the software that would govern how the computers would communicate.[2]
  - Steve Crocker: a grad student (bachelors the previous year) became the default leader.

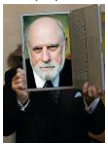
http://isoc.org/

1 Stephen Crocker, The Request For Comments Reference Guide, RFC 1000, Aug. 1987

2 "A History of the Internet and the Digital Future" (Johnny Ryan)

The UCLA Lab (3)

- Two other grad students were classmates of Crocker at Van Nuys High (and graduate students of Leonard Kleinrock).
- Vint(on) Cerf: was another early participant of the group.



www.elpias.com

RFCs[1]

- The students would issue notes on the (eventual) Internet protocols under the name RFC (Request For Comments).
  - They were established by Crocker as an informal way to share ideas with other network researchers (and to get feedback).
- Conventions for issuing the notes were informal to minimize claims over the different parts of the work and to encourage participation.
- In this vein the first RFC was generated in rather humble circumstances by Crocker (Very late/early: April 7 1969).

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1 "A History of the Internet and the Digital Future" (Johnny Ryan, Reaktion Books)

RFCs (2)

- The RFCs were in a perpetual beta state.
  - (Change/updating)
    - No text was to be considered authoritative.
    - There is no final edit.
  - (Democratic)
    - Authority was merit based rather than based on authority from a fixed hierarchy.
- NCP (Network control protocols) was the first fruit of the labors of the RFCs and governed communication between the machines.
  - December 1970: The Network Working Group (NWG) under S. Crocker produced the host-to-host protocol.[1]

1 "A brief history of the Internet" (Barry M. Leiner, Vinton G. cerf, David D. Clark, Robert E. Kahn, Leonard Kleinrock, Daniel C. Lynch, Jon Postel, Larry G. Roberts, Stephen Wolff, http://www.isoc.org/oti/articles/0597/leiner.html (last accessed July 2011).

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RFCs (3)

- The first data packet sent using the NCP was in 1976:

Zott's

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Vinton Cerf And Robert Kahn

- Some regard Vint Cerf (and perhaps Robert Kahn) as the grandfather of the Internet.
  - Al Gore's influence (to be covered later in this section).
- Eventually Cerf left ARPA to become a professor at Stanford.
- Robert Kahn was an MIT mathematics professor on leave to work on the ARPANET project (1972)[1,2]
  - By this time ARPA was renamed DARPA (D = Defense)
- NCP (Network Control protocol) relied on the ARPANET's stability to provide reliability of the connection and transmission of information.

1 "A brief history of the Internet" (Barry M. Leiner, Vinton G. cerf, David D. Clark, Robert E. Kahn, Leonard Kleinrock, Daniel C. Lynch, Jon Postel, Larry G. Roberts, Stephen Wolff, http://www.isoc.org/oti/articles/0597/leiner.html (last accessed July 2011).

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2 "The Ancient History of the Internet" (Edwin Diamond , Stephen Bates): American Heritage Pct 95: Vol. 46, Issue 6

Vinton Cerf And Robert Kahn (2)

- Having the ARPNET responsible for the reliability of the 'network of networks' was acceptable when the ARPANET was not connected to other networks.[1]
- This was no longer acceptable when other networks were connected to the ARPANET:
  - ARPANET
  - PRNET (Packet radio Network)
  - SATNET (Satellite radio Network)
  - NCP only worked on certain types of computers.[2]

1 "A brief history of the Internet" (Barry M. Leiner, Vinton G. cerf, David D. Clark, Robert E. Kahn, Leonard Kleinrock, Daniel C. Lynch, Jon Postel, Larry G. Roberts, Stephen Wolff, http://www.isoc.org/oti/articles/0597/leiner.html (last accessed July 2011).

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2 "History of the Internet", www.historyofthings.com (Last accessed July 2011)

Vinton Cerf And Robert Kahn (3)

- 1973 - 1974: Kahn and Cerf published an outline of the new protocol to allow the 3 networks to communicate.
  - This protocol was known as: TCP (Transmission control protocol)
  - It would allow different types of computers to communicate despite varying packet sizes and different hardware capabilities.[1]

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1 "The Ancient History of the Internet" (Edwin Diamond , Stephen Bates): American Heritage Pct 95: Vol. 46, Issue 6

Vinton Cerf And Robert Kahn (4)

- With this new protocol the host computers (and not the less powerful IMP computers) were now responsible for the connections.
- Similar to Baran's (nuke-proof) network TCP focused on robustness over central control (a source of confusion for the purpose of the Internet).
- Late IP (Internet protocol) was developed and added to handle communications between networks.

• 1977: Testing the robustness of the protocol

• January 1, 1983: the transition was made from

Vinton Cerf And Robert Kahn (5)

• At this point, ARPA was no longer funding pure computer science research, instead it worked on "militarily interesting" (Vint Cerf) like this one.[1]

• When microcomputers (desktop) appeared there was skepticism that the hardware could handle the big and complex TCP protocols.[2]

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Vinton Cerf And Robert Kahn (6)

• This belief was disproven with a demonstration by researchers at MIT who connected: (1) A Xerox workstation (2) and then an IBM PC.[1]

1 "A brief history of the Internet" (Barry M. Leiner, Vinton G. cerf, David D. Clark, Robert E. Kahn, Leonard Kleinrock, Daniel C. Lynch, Jon Postel, Larry G. Roberts, Stephen Wolff, http://www.isoc.org/oti/articles/0597/leiner.html (last accessed July 2011).

Four Ground Rules Critical To Kahn's Early Thinking[1]

1. Each network would be distinct:
   - It should be able to stand on its own and no internal changes should be needed in order to connect to the Internet.
2. Communications would be done on a best effort.
   - If at first (a packet) doesn't not succeed (in a send)…retransmit, retransmit, retransmit again!
3. Black boxes (eventually named gateways or routers) would connect the networks.
   - Pass information from network-to-network.
4. There would be no global control of the operations of the network.

1 "A brief history of the Internet" (Barry M. Leiner, Vinton G. cerf, David D. Clark, Robert E. Kahn, Leonard Kleinrock, Daniel C. Lynch, Jon Postel, Larry G. Roberts, Stephen Wolff, http://www.isoc.org/oti/articles/0597/leiner.html (last accessed July 2011).

PRNET[1] (Packet Radio Network)

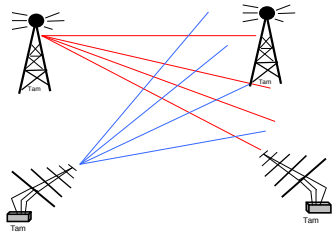
• It came out of the work out at the University of Hawaii.

• The university needed to connect (network) the 7 campuses which were spread across 4 islands.
  - Leased telephone lines were expensive and too poor in quality to carry the data so researchers looked to radio transmissions.
  - Unlike point-to-point phone signals, radio indiscriminately sent to all receivers that are within range.
  - Information broadcast by different parts of the network could collide and destroy each other.

1 "A History of the Internet and the Digital Future" (Johnny Ryan, Reaktion Books)

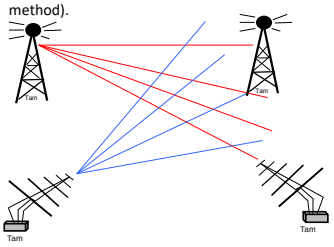
PRNET (2)

– Immediately resending the packets wasn't a solution!



PRNET (2)

– 1969: A simple but effective solution was implemented (the Aloha method).



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PRNET (4)

- Solving the problem of transmitting packets via radio was timely.
- The US senate had just cut $400 million from defense spending.
- Now all funded research must have a direct and apparent relationship to a specific military function.
- The Department of Defense not only wanted to use the capabilities of the mainframes centrally (Pentagon) but also in the field (deployed troops).[1]
  - Placing mainframes in or near combat zones was obviously not feasible.
  - The solution was to have (weaker) portable computers communicating with the mainframe.
  - Existing infrastructure (telephone lines) was too vulnerable.
    - Direct connection needed, if lost it had to be re-established.

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1 "The Ancient History of the Internet" (Edwin Diamond , Stephen Bates): American Heritage Pct 95: Vol. 46, Issue 6

PRNET (5)

- The Aloha method would allow the US Central Command's mainframes to communicate with troops 'in the field'.
  - It didn't require wired telephone connections.
  - It used packets rather than a direct point-to-point connection.

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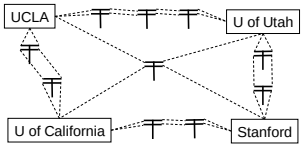
The Centrifugal Nature Of The Internet

1. Messages don't take a single path (and 'lock' that route) like telecommunication information (land line telephone calls).



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The Centrifugal Nature Of The Internet (2)

2. Instead of centralized control, control is delegated to individual hosts (each host is equal to another) rather than a central host.

JT's comment: This is one reason why the Internet of today may seem like the lawless "wild west".

James Tam

Email

- March 1972: Ray Tomlinson wrote the first 'hot' application: email (software to send/receive text messages).
- Motivation: To provide ARPA developers an easy way of coordinating their work.[1]
  - Mailing lists allowed large groups of people to discuss a topic via an asynchronous mass medium as opposed to a synchronous point-to-point one.[2]
    - The first mailing list: SF-LOVERS
    - Soon it was joined by many others: NETWORK-HACKERS, WINETASTERS etc.

1 "A brief history of the Internet" (Barry M. Leiner, Vinton G. cerf, David D. Clark, Robert E. Kahn, Leonard Kleinrock, Daniel C. Lynch, Jon Postel, Larry G. Roberts, Stephen Wolff, http://www.isoc.org/oti/articles/0597/leiner.html (last accessed July 2011).

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Email (2)

- Email remained the most popular application the network for over a decade.
  - 75% of ARPA network traffic was email.[1]

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1 "On the Way to the Web" (Michael A. Banks, Wiley)

Transition from ARPANET To The Modern Internet[1]

- The exact time is unclear, there are no precise milestones.
- The original idea was that there would be multiple independent networks.
  - Each network would be separately designed and maintained.
    - Each one would suit the needs of it's individual users and not 'The Internet' as a whole.
  - The first of these networks was the ARPANET.
    - But others were soon connected (PRNET, SATNET etc.)
- Things that helped increase the usage of the early Internet[1]:
  - AT&T's free distribution of USENET (Online discussion groups).
  - The rise of national commercial networks (ISP's such as PSI, UUNET, ANS CO+RE (for-profit subsidiary of the non-profit Advanced Network and Services etc.

1 "A brief history of the Internet" (Barry M. Leiner, Vinton G. cerf, David D. Clark, Robert E. Kahn, Leonard Kleinrock, Daniel C. Lynch, Jon Postel, Larry G. Roberts, Stephen Wolff, http://www.isoc.org/oti/articles/0597/leiner.html (last accessed July 2011).

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Transition from ARPANET To The Internet

- (Factors that increased the popularity of the early Internet):
  - 1970s: Ethernet allowed for a fast and easy way to transport data.
    - Ethernet cables made network connectivity easier and faster.[1]
    - The increased use of networks increased the size of the Internet.
  - 1988: A National Research Council committee (Kleinrock, Kahn and Clark) produced a report "Towards a National Research Network".
    - It influenced (then senator) Al Gore
    - Q: Did Al Gore invent the Internet? Why was its invention attributed to him?

Public domain from https://www.usa.gov/

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1 "History of the Internet", www.historyofthings.com (Last accessed July 2011)

Transition from ARPANET To The Internet (2)

  - The World Wide Web (WWW) was a major factor…more on this later.
- 1980s[1]:
  - While the ARPANET was created for military purposes, some organizations using it (e.g., universities, business etc.) found it useful for other purposes.
  - Also the US department of defense realized that having military data/programs was a security risk.

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1 "History of the Internet", www.historyofthings.com (Last accessed July 2011)

Transition from ARPANET To The Internet (2)

- 1980s (continued)[1]
  - The ARPANET was split into two parts:
    - MILNET: military.
    - ARPANET: non-military.
  - MCI upgraded the telephone connections from 56Kbps (1985) to new T-1 lines 1.5 Mbps (1988).
  - NSFNET went online in 1986: IBM upgraded the rest of the network (routers) to take advantage of the upcoming T-1 lines.
- 1991:
  - T-3 lines used for the Internet (45 Mbps).

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1 "History of the Internet", www.historyofthings.com (Last accessed July 2011)

The History Of The World Wide Web

From www.computerhistory.org (2012)

- Designed in 1989 by Tim Berners-Lee and scientists in Geneva who were interested in making it easier to share research documents.
- Documents could be linked through a protocol called http (hyper text transfer protocol).
- Documents were made available for free browsing and downloading from the web (*substantially* easier than the alternative).
  - Initially there was no interest
- 1990:
  - The first web browser "WorldWideWeb" (later renamed 'Nexus'[1] was written.

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1 http://www.w3.org/People/Berners-Lee/WorldWideWeb.html

The History Of The World Wide Web (2)

- 1993:
  - Mark Andreessen of NCSA (National Center for Super Computing Applications) launched Mosaic X the first popular web browser.
- 1993 Mark Andreesen of NCSA (National Center for Super Computing Applications) launched Mosaic X the first popular web browser.[1]
  - 1995 Mosaic became Netscape.
  - Many consider the IPO (initial public [stock] offering) of Netscape to be the start of the Dot-com stock boom.
  - Mid 1990s: Netscape share of the browser market ~85%.
  - Microsoft initiated an extremely successful campaign to promote their browser by bundling it with their operating system.
  - 2003: Netscape held ~1% of the market (now defunct).

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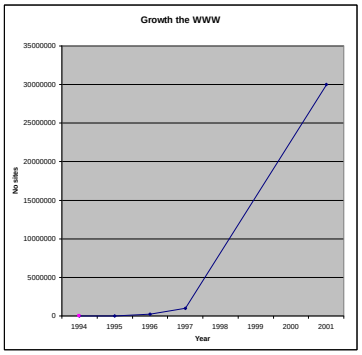
1 "History of the Internet", www.historyofthings.com (Last accessed July 2011)

The Growth Of The World Wide Web



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The Impact of the Web

- Prior to the advent of the WWW the Internet was largely used by a niche user group.
- The advent of the WWW drastically changed that.
- With so much information available there were many who tried to come up with a way to find the information (thus the rise of the search engines)….more on this in the 'search' section.

James Tam

You Should Now Know

- How the roots of the Internet stem from the second World War and the Cold War
- What was the major motivation behind the formation of the research group (ARPA), that lead to creation of the Internet when did this occur
- ARPA
  - What is ARPA and the ARPANET
  - What motivated its formation, who was the source of it's funding and why
  - When was it founded, what were some of its major milestones and when did they occur
  - What was its research mandate and areas of focus over time, what was its core focus
  - Who were some of the people involved in this research group and how did they infleunce ARPA
  - What research groups were involved in its early formation
  - How was the work at ARPA influenced by the work of other research groups

James Tam

You Should Now Know (2)

- Packet switched networks
  - How did the idea of such a network originate
  - How does packet switched networks work and how does it differ from a traditional telephone network
- Internet protocols
  - What role did/do protocols have on the creation and operation of the Internet
  - What were some of the protocols used and when, who developed them
  - What were some of the events in the creation and testing of these protocols

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You Should Now Know (3)

- RFC
  - What is an RFC
  - What are the characteristics of an RFC and how is this related to the nature of the Internet
  - What role did RFCs play in the formation of the Internet
  - Who was behind their creation and early use
- Who were the important people were behind the creation and continued development of the Internet, how did they did affect its development

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You Should Now Know (4)

- PRNET
  - What is it
  - What was the motivation behind its creation
  - How did it effect the development of the Internet
  - How does the Aloha method of transmission work and what role did it play in the formation of the Internet
- What was the first hot application of the Internet and how was it initially used
- How did the initial ARPANET eventually transition to the modern Internet
  - What were some of the factors that increased usage, what was attributed as the major contributing factor

You Should Now Know (5)

- WWW (World Wide Web)
  - What was the motivation behind its creation
  - Who was its creator, what organization was involved
  - What were some of the major milestones in the WWW and when did they occur

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