INFO/CS 4302
Web Information Systems

FT 2012
Week 2: Internet History & Architecture (Part1)

Theresa Velden

Introduction

- Popular opinions on how the Internet was invented:

Introduction

- Popular opinions on how the Internet was invented:
  - O Tim Berner’s Lee

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Introduction

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  - O Tim Berner's Lee
  - O Al Gore
  - O Xerox
  - O The military
  - O Many people: government funded researchers working with corporations

Introduction

- What are some of the technical key components that make up **the Internet**?

The History of The Internet

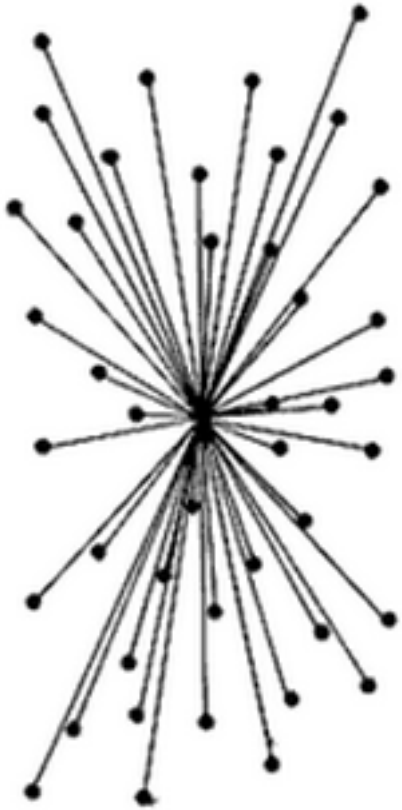
The History of The Internet

Movie by Melih Bilgil

http://www.youtube.com/watch?v=qpcU25OAcj0

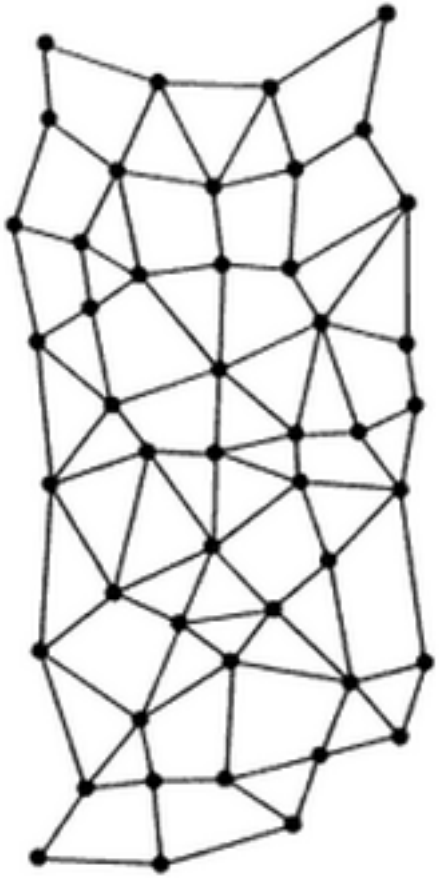
Internet Architecture

De-centralized network design



centralized

(Paul Baran,RAND
early 1960s)

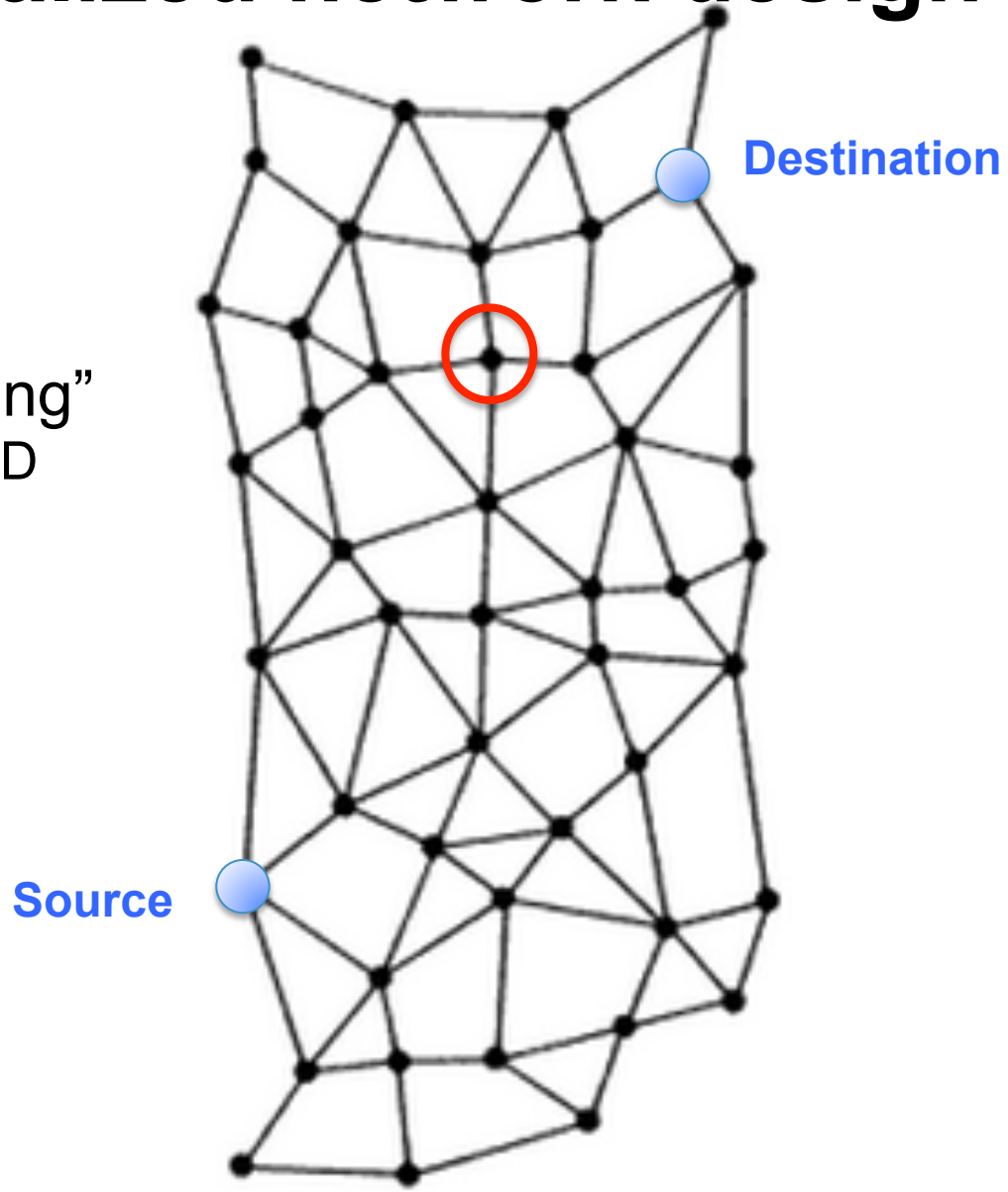


distributed

Images: RAND (http://www.rand.org/about/history/baran.list.html)

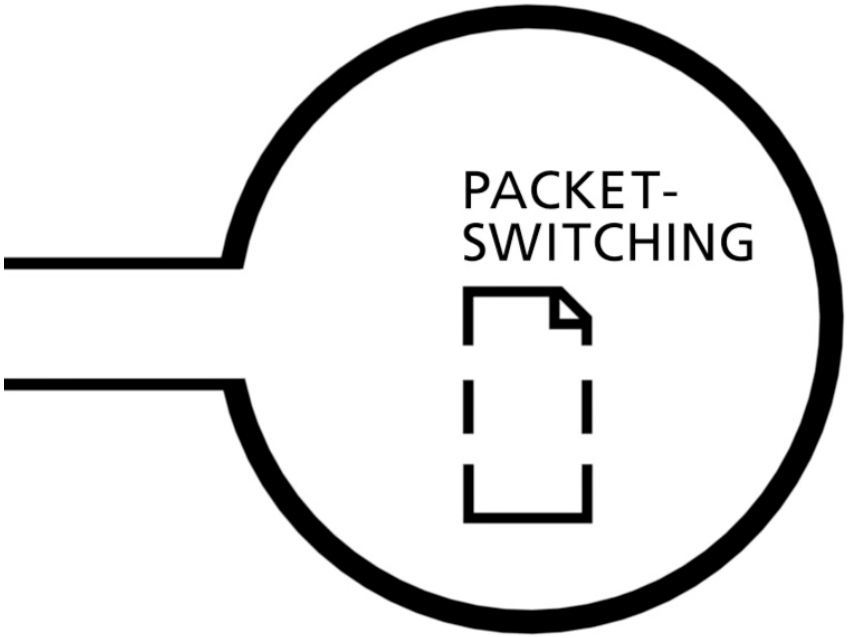
De-centralized network design

"hot-potato routing"
(Paul Baran,RAND
early 1960s)



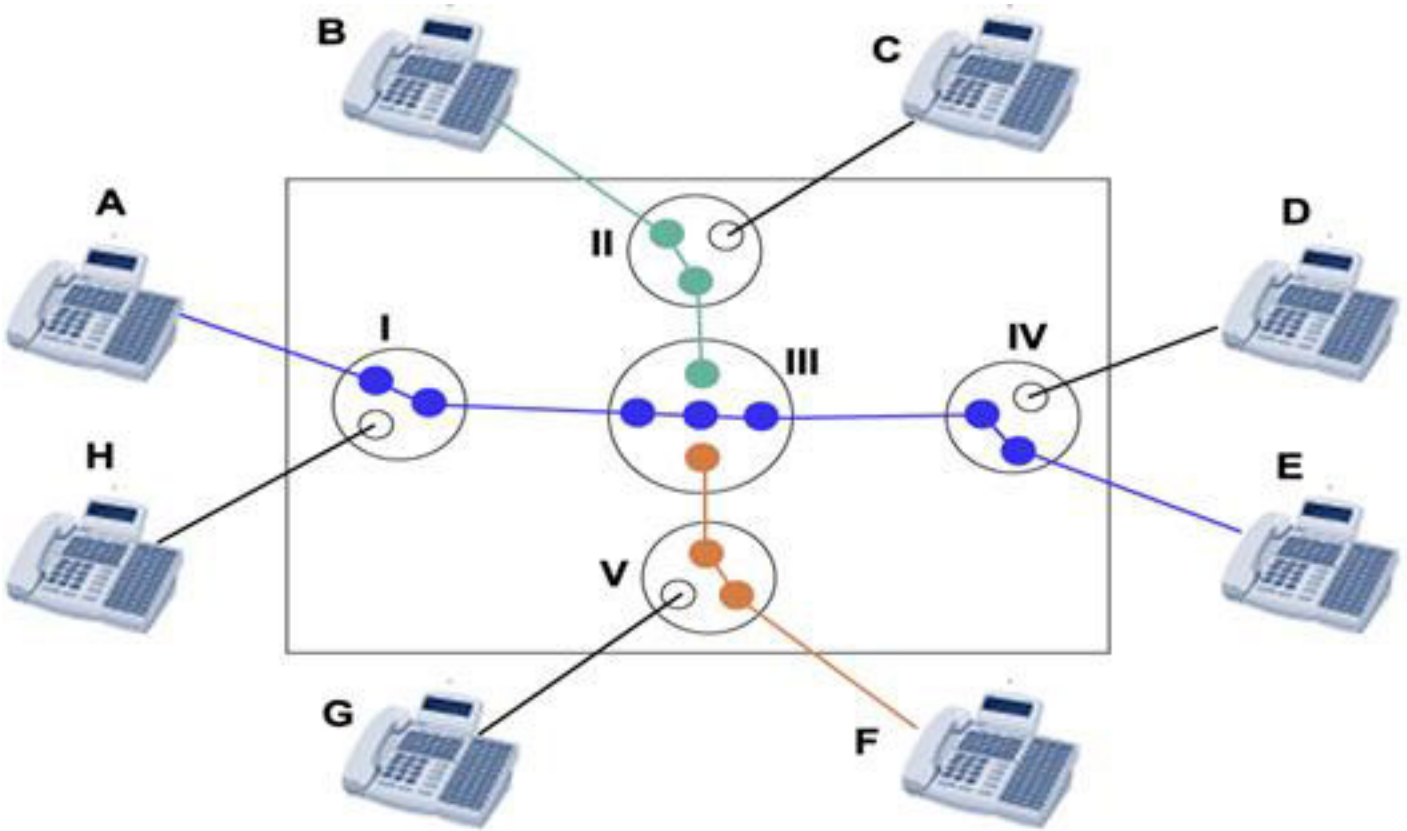
packet switching (early 1960's)

Kleinrock (MIT) | Paul Baran (RAND) | Donald Davies (NPL, UK)

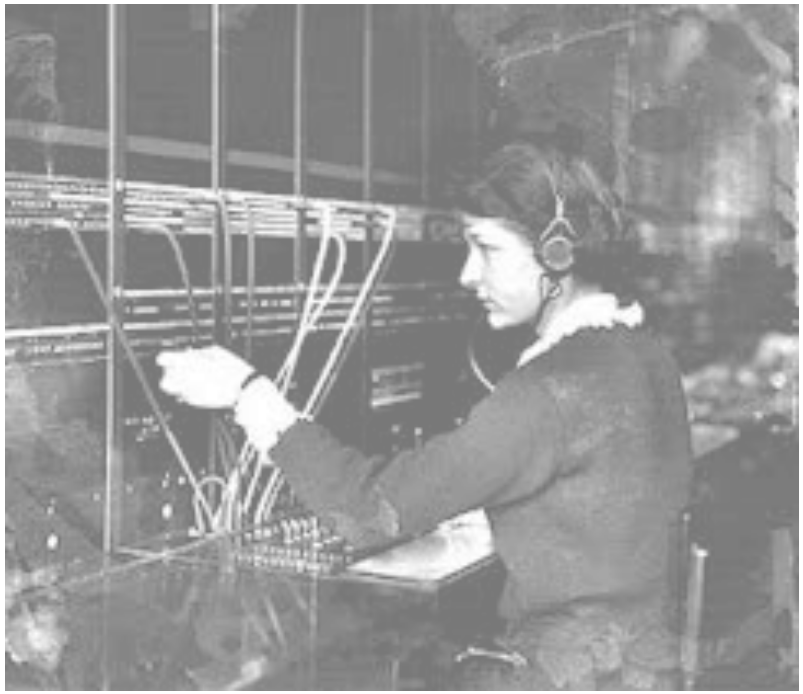


- Communication divided in equal sized packages (up to 1 Kilobyte)
- Each packet with a header with packet, source and destination information
- Each Internet router determines path
- Message (re)assembly at destination

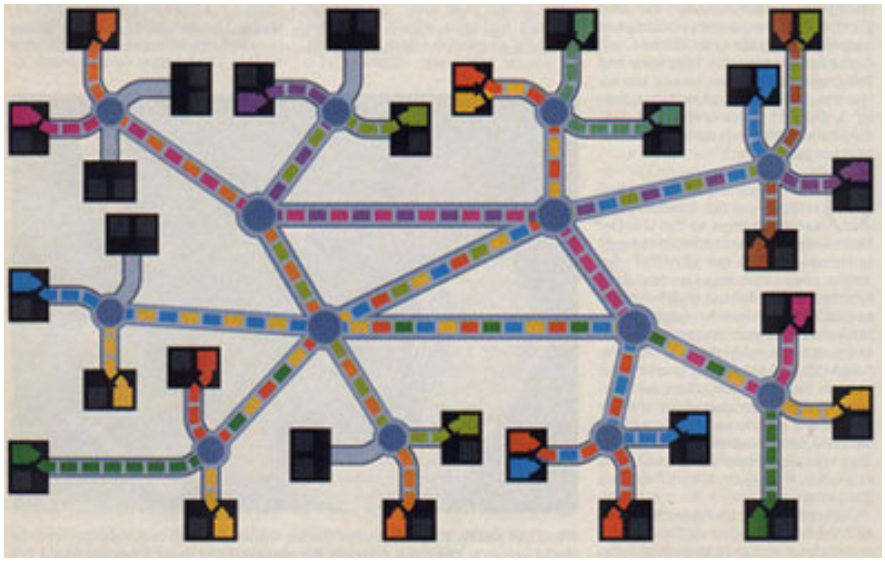
Circuit switching



circuit switching vs. packet switching



- Dedicated line for entire conversation incl. silences (-)
- Less efficient (-)
- More reliable (+)



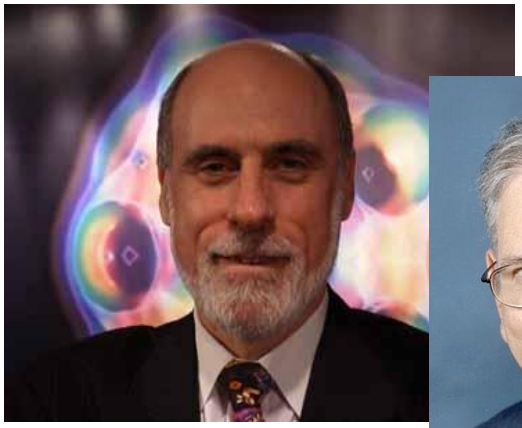
[From: http://digitalfewsure.typepad.com/]

- Full band with for each packet (+)
- More efficient (+)
  - Users share network
  - Resource use only when needed
- Less reliable (-)

Routing algorithms

See Homepage Theo Schouten: http://www.cs.ru.nl/~ths/a3/html/h5/h5.html

TCP & IP
(1978)



Vinton Cerf

Bob Kahn

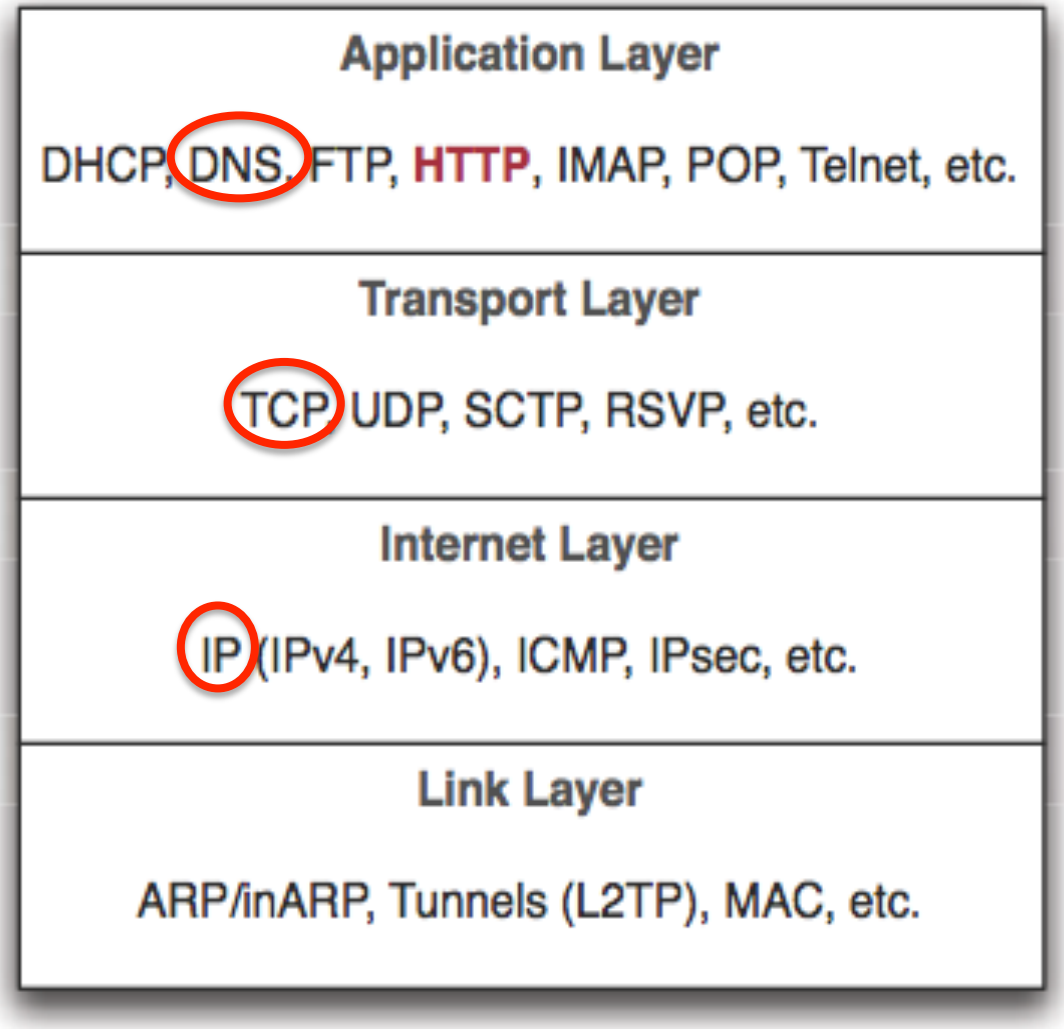
TCP/IP Protocol Suite:

user application

packet re-assembly

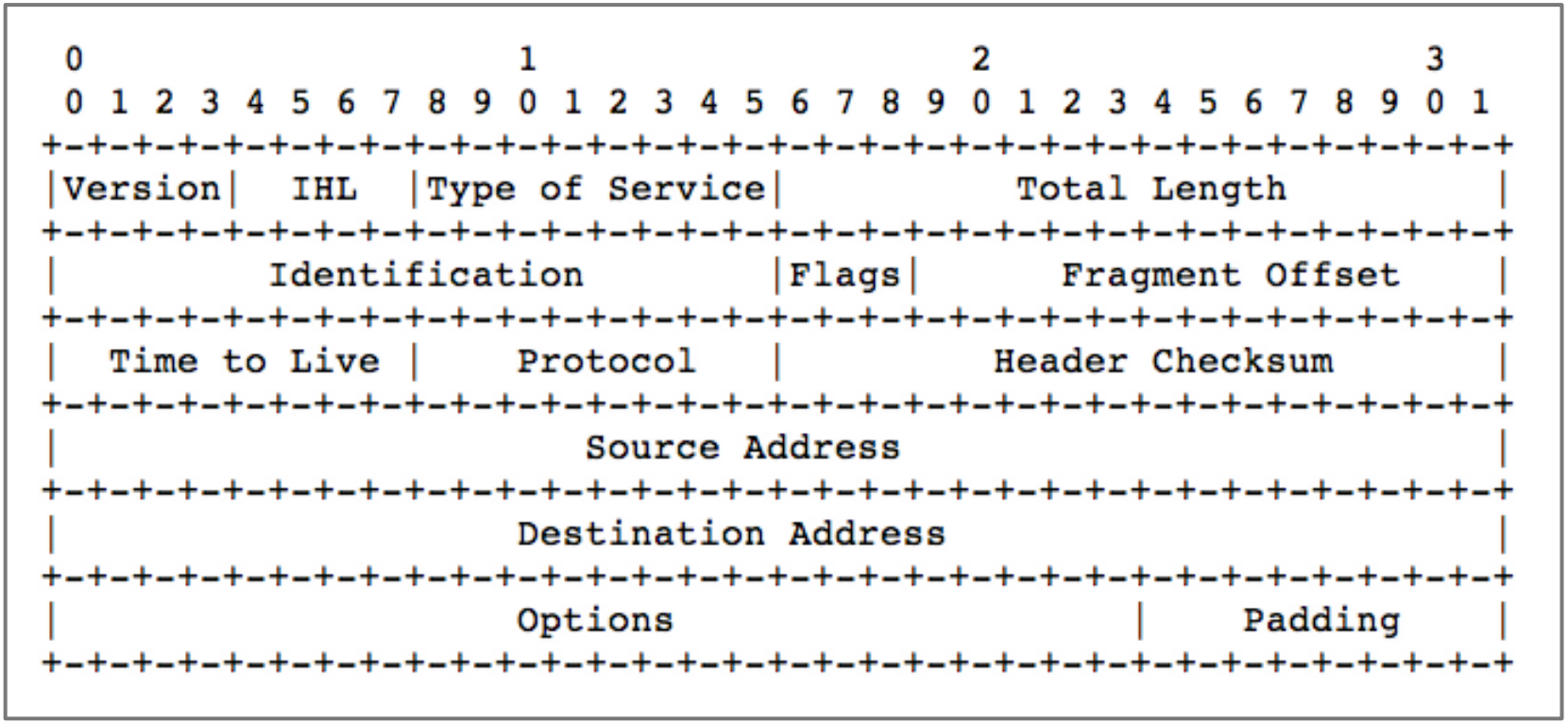
packet delivery

hardware address resolution



IP = Internet Protocol

- Rules for sending and receiving data: **addressing** and **routing**
- Datagram: header + payload

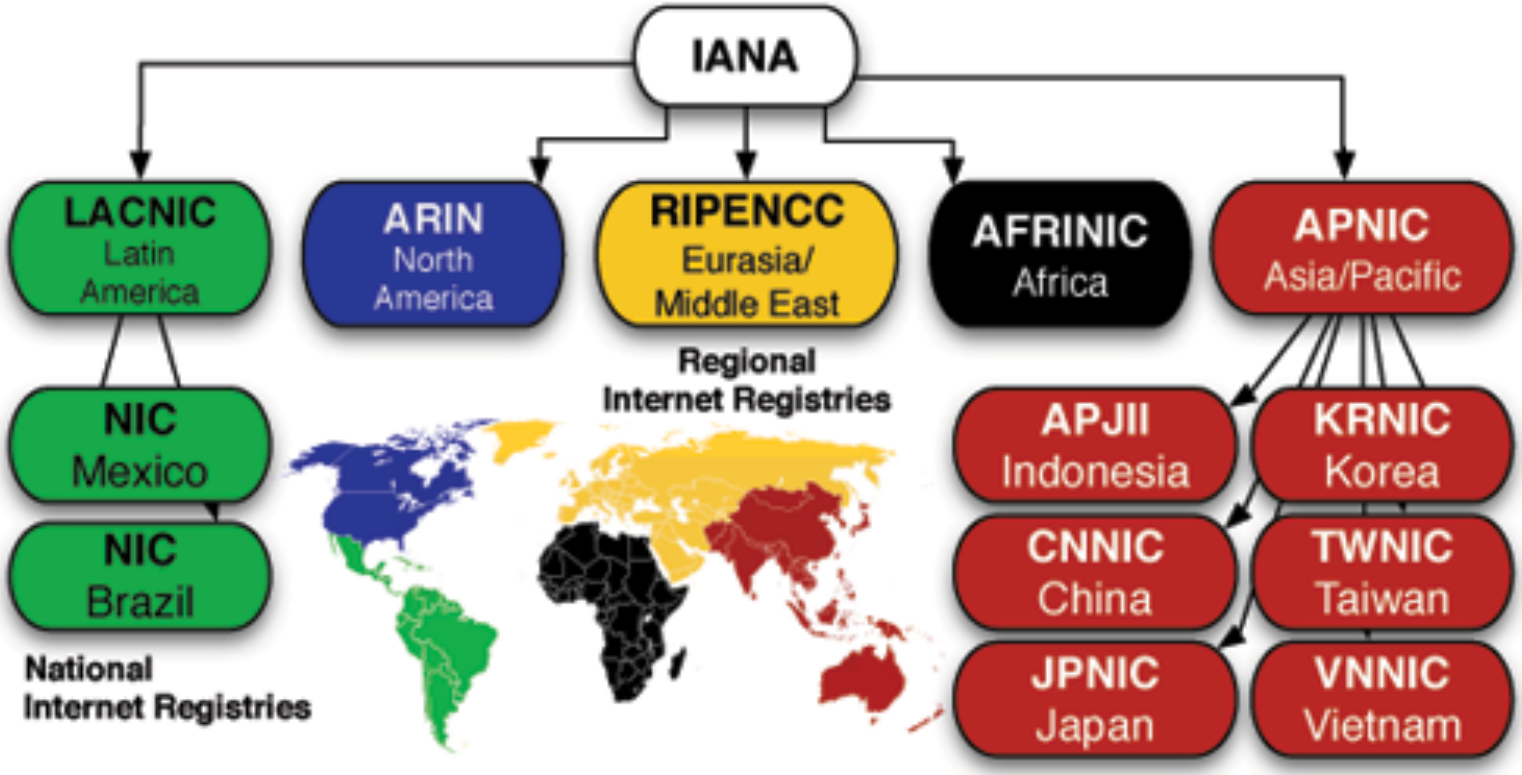


Source: RFC 791

IP = Internet Protocol

- Hides underlying heterogeneity (ether, cable, wireless…)
- Connection-less (packets routed individually)
- ‘best effort at delivery’, unreliable (packets may be dropped)
- Unique hierarchical addressing scheme for computers on network (needed for routing)

IP Addresses:
5 regional internet registries (RIRs)



Global pool of PIv4 addresses was exhausted early in 2011
IANA: Internet Assigned Numbers Authority

IP Addresses

	Internet Protocol version 4 (IPv4)	Internet Protocol version 6 (IPv6)
Deployed	1981	1999
Address Size	32-bit number	128-bit number
Address Format	Dotted Decimal Notation: 192.149.252.76	Hexadecimal Notation: 3FFE:F200:0234:AB00: 0123:4567:8901:ABCD
Prefix Notation	192.149.0.0/24	3FFE:F200:0234::/48
Number of Addresses	2^{32} = ~4,294,967,296	2^{128} = ~340,282,366, 920,938,463,463,374, 607,431,768,211,456

(From: http://www.caribnog.org/articles/addressing-ipv6-in-the-caribbean/ Bevil Wooding, Adressing IPv6 in The Carribean, June 2012)

TCP = Transfer Control Protocol

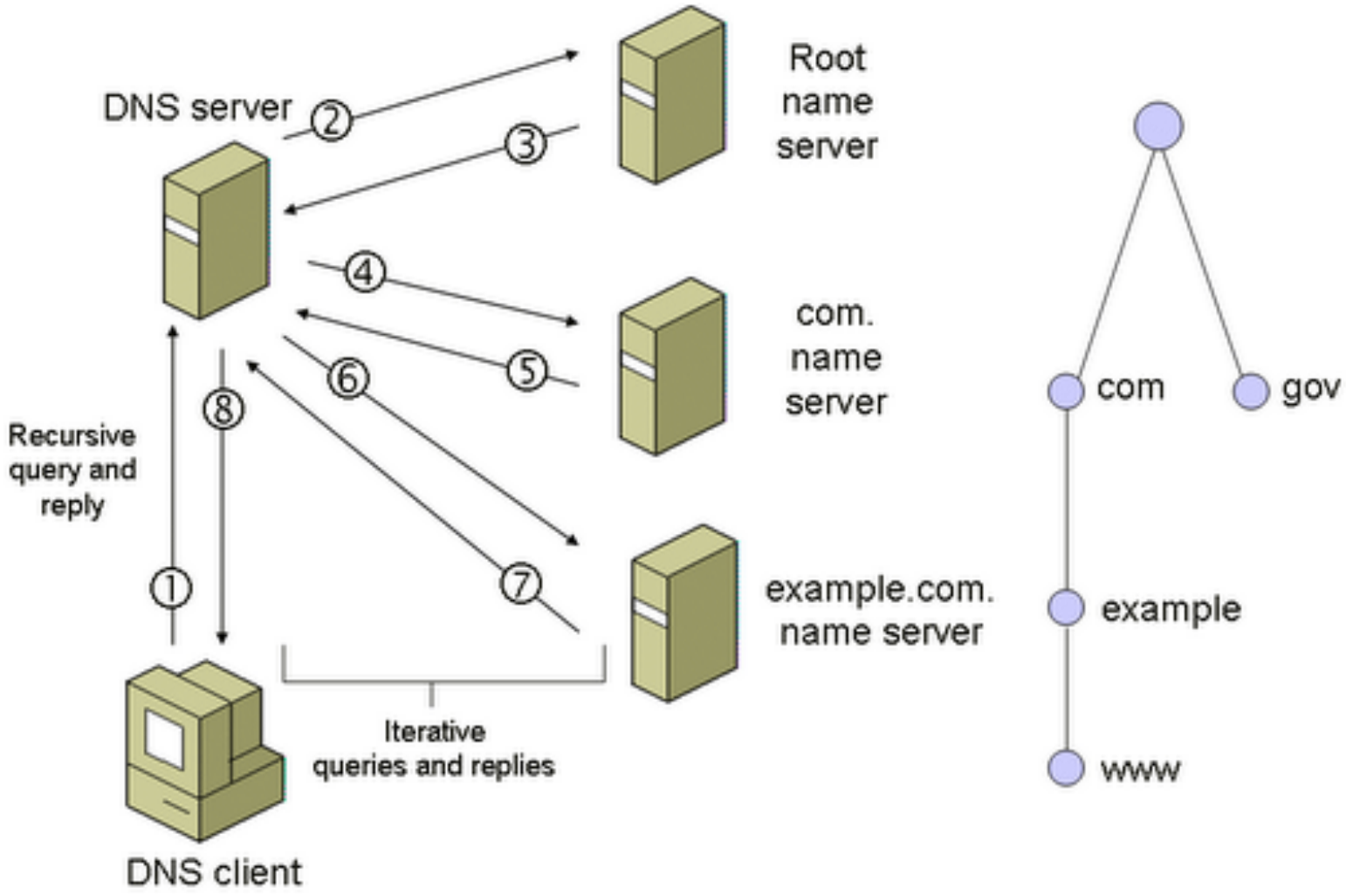
- Flow controlled (to avoid congestion)
- Reliable
  - No data lost or duplicated (re-transmit)
  - Serial numbers for packets
  - Different from **UDP**: ‘state-less’ (careless) used for streaming
- Connection-oriented (‘virtual circuits’)

DNS = Domain Name Resolution

- Invented in 1983 by Paul A Mockapetris at University of Southern California
- Allows us to memorize ‘names’ rather than 32 bit or 128 bit numbers
- Domain names: define realm of autonomy
- Hierarchical:
  - Top level domains: country codes, e.g. **.jp**, **.uk**, or generic: **.com**, **.edu**, **.org** etc.
  - Second-level domains: **cornell**.edu
  - Third-level domains: e.g. **cs**.cornell.edu
- Distributed and dynamic database (name servers)
  - 13 root name servers http://www.root-servers.org/

Paul A Mockapetris

DNS – Domain Name Resolution



[Joe Davies, Microsoft TechNet http://technet.microsoft.com/en-us/library/bb727007.aspx]

Realization of The Internet

JCR Licklider (MIT)

Lawrence G. Roberts (MIT)

- 1962 J.C.R. Licklider: series of memos ‘Galactic Network’ (MIT), ARPA IPTO Director
- 1967 ‘plan for ARPANET’ by Lawrence G. Roberts (MIT), Designer and Manager
  - **Motivation: time sharing and communication to avoid duplication of efforts**
- 1969 first **4 computers** networked together (UCLA, Stanford, Utah, Santa Barbara)
- 1973 Ethernet (optical cable)
- 1983 military and research network split (MILNET), about **200 computers** on the Internet [Cerf 1995], 1981 CSNET, 1986 NSFNET
- 1989 ARPANET renamed ‘Internet’, commercial ISPs emerge
- 1995 NSFNET decommissioned, commercial restrictions lifted

Internet Governance & Standardization

Internet Governance

By independent, non-for-profit membership organizations:

- Open
- Self-regulated

Source:
http://www.internetsociety.org/internet/how-it-works/technical-aspects

Internet Governance

- Internet Society (ISOC, since 1992) – Evolution, social & political issues; promotion of international standards http://www.isoc.org/
- Internet Architecture Board (IAB) – Oversees standards process http://www.iab.org/
- Internet Engineering Task Force (IETF) – standards development http://www.ietf.org/
- Internet Corporation for Assigned Names and Numbers (ICANN)
  - DNS administration | IP # assignment | Protocol #'s | port #'s
    – Operates under contract with U.S. Department of Commerce (this is controversial!) http://www.icann.org/

Further reading: 'A concise guide to the major internet bodies' by Alex Simonelis (2005) http://ubiquity.acm.org/article.cfm?id=1071915

Request For Comments (RFC)

http://www.rfc-editor.org/

Network Working Group
RFC-3

4689
April 1969
Steve Crocker
UCLA

DOCUMENTATION CONVENTIONS

The Network Working Group seems to consist of Steve Carr of Utah, Jeff Rulifson and Bill Duvall at SRI, and Steve Crocker and Gerard Deloche at UCLA. Membership is not closed.

The Network Working Group (NWG) is concerned with the HOST software, the strategies for using the network, and initial experiments with the network.

Documentation of the NWG's effort is through notes such as this. Notes may be produced at any site by anybody and included in this series.

CONTENT

The content of a NWG note may be any thought, suggestion, etc. related to the HOST software or other aspect of the network. Notes are encouraged to be timely rather than polished. Philosophical positions without examples or other specifics, specific suggestions or implementation techniques without introductory or background explication, and explicit questions without any attempted answers are all acceptable. The minimum length for a NWG note is one sentence.

These standards (or lack of them) are stated explicitly for two reasons. First, there is a tendency to view a written statement as ipso facto authoritative, and we hope to promote the exchange and discussion of considerably less than authoritative ideas. Second, there is a natural hesitancy to publish something unpolished, and we hope to ease this inhibition.

FORM

Every NWG note should bear the following information:

1. "Network Working Group"
   "Request for Comments:" x
   where x is a serial number.
   Serial numbers are assigned by Bill Duvall at SRI

2. Author and affiliation

3. Date

4. Title. The title need not be unique.

IEN 149
RFC 765

J. Postel
ISI
June 1980

FILE TRANSFER PROTOCOL

INTRODUCTION

The objectives of FTP are 1) to promote sharing of files (computer programs and/or data), 2) to encourage indirect or implicit (via programs) use of remote computers, 3) to shield a user from variations in file storage systems among Hosts, and 4) to transfer data reliably and efficiently. FTP, though usable directly by a user at a terminal, is designed mainly for use by programs.

The attempt in this specification is to satisfy the diverse needs of users of maxi-Hosts, mini-Hosts, and TIPs, with a simple, and easily implemented protocol design.

This paper assumes knowledge of the following protocols described in the ARPA Internet Protocol Handbook.

The Transmission Control Protocol

The TELNET Protocol

DISCUSSION

In this section, the terminology and the FTP model are discussed. The terms defined in this section are only those that have special significance in FTP. Some of the terminology is very specific to the FTP model; some readers may wish to turn to the section on the FTP model while reviewing the terminology.

TERMINOLOGY

ASCII

The ASCII character set as defined in the ARPA Internet Protocol Handbook. In FTP, ASCII characters are defined to be the lower half of an eight-bit code set (i.e., the most significant bit is zero).

access controls

Access controls define users' access privileges to the use of a system, and to the files in that system. Access controls are necessary to prevent unauthorized or accidental use of files. It is the prerogative of a server-FTP process to invoke access controls.

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The end-to-end principle

> The function in question can completely and correctly be implemented only with the knowledge and help of the application standing at the end points of the communication system. Therefore, providing that questioned function as a feature of the communication system itself is not possible. (Sometimes an incomplete version of the function provided by the communication system may be useful as a performance enhancement.) [1].

Saltzer, J.H., Reed, D.P., and Clark, D.D., "End-to-End Arguments in System Design," ACM TOCS, Vol 2, Number 4, November 1984, pp 277-288.

- Functionality added at end points and transparent at mid-points
- Maximal flexibility for client to customize and innovate at the end points

Recap (take away)

Recap (take away):

- Internet ≠ World Wide Web

- Principles of Internet Design
  - Distributed
  - Open
  - End-to-end

Outlook

- Thursday:
  - A look at the Internet today
  - Hands-on: Internet protocols
- Next Week:
  - The History and the Architecture of the World Wide Web

Reminders

- Homework 1 is due on Sunday 11:59pm (submission via the CMS)
- Subscribe to the course on piazza

Resources used

- Internet Pioneers: http://www.ibiblio.org/pioneers/index.html
- V Cerf 'Computer Networking – Global Infrastructure for the 21st Century' (1995) http://www.cs.washington.edu/homes/lazowska/cra/networks.html
- RAND corporation website
- Internet Society http://www.internetsociety.org/internet/how-it-works/technical-aspects
- Computer History Museum http://www.computerhistory.org/internet_history/
- Lecture slides INFO/CS4302 by Carl Lagoze