TCP/IP intro

Jim Binkley
http://www.cs.pdx.edu/~jrb
jrb@cs.pdx.edu

Very Brief Internet History

- 1957 Sputnik/USSR. US creates ARPA
- 62 - Paul Baran, packet-switches (missiles)
- 69 -ARPA/DOD starts ARPANET
- 71 - 15 nodes
- 73 - Ethernet/Bob Metcalfe Harvard Ph.D
- 79 - USENET/UUCP over modems
- 82/83 Darpa starts using TCP/IP on Arpanet
- 83 - BSD UNIX with TCP/IP, enet

Inet history, cont

- 84 - DNS and 10k hosts
- 88 - 6k/of 60k hosts visited by Morris worm
- 89 - IETF and IRTF under IAB
- 92 - 1st MBONE audio/video over Inet
- 93 - Hillary is root@whitehouse.gov
- 93 - WWW begins to take over
- 94 - businesses and biz begin to take over
- 94 - gov. decides OSI not best idea...

citations:

- 95 - NSFNET replaced by commercial backbones
- 93-now Internet does not fail ...
- 2002 - term “switch” no longer refers to circuits ...
- See **Hobbes Internet Timeline**: RFC 2235
- http:info.isoc.org/guest/zakon/Internet/History/HIT.html for most of these

Internet Growth - DNS surveys in the past

Date	*Hosts*	*Nets*	*Domains*
1969	4		
1984	1024		
1987	28174		
1989	130000	650	3900
1990	313000	2063	9300
1992	727000	4526	
1993	1313000	7505	21000
7/94	3212000	25210	46000
7/95	6.6 M	?	120000
7/96	12.8M	?	488000
97	20-30M	45/55k	>1m
04	???	150k	66m

note: scalability issues

- # ip addresses, # ip nets
  - IPv6 may address this
- # dns names (variation, too many .com)
  - there are only a handful of DNS root servers
- # of routes in routers
  - CIDR - classless internet domain routing
  - IPv6 doesn't help, process issue, not architecture issue so much

recent information

- see http://www.cidr-report.org
- IPv4 allocated addresses run out in 2019
- allocated versus used issue …
  - define “run out”
- allocation from IANA to Regional Registry
  - to ISP to you
- BGP IPv4 routes at around 190000 - 2006
- # of hosts??? dns names irrelevant
  - www.badmovieoftheweek.com
- 66 million DNS names acc. to Verisign

more info

- allocate from class A/C now, B used up
- 57% of IPv4 address space is allocated as of 2004
- 31% is advertised
- IPv6 might have a thousand or so routes in core routing tables

world-wide data net vs telco/voice

- source: Insight Research Corp, and Boardwatch, August 2000
- world network demand - billions of packets
- 1996 - data=135, voice=948
- 1999 - data=1572, voice=1511
- 2000 - data=4451, voice=1766
- 2002 - data=27645, voice=2063
- voice has turned into *data* with VOIP

Some count # of Inet hosts

- US now #1, China #2 (> 100 million each)
- note this statistic (acc. to FBI last year)
- country in world #1 in Inet attacks
  - US
- country in world #2 in Inet attacks
  - China
- matches up pretty well with number of hosts in the world

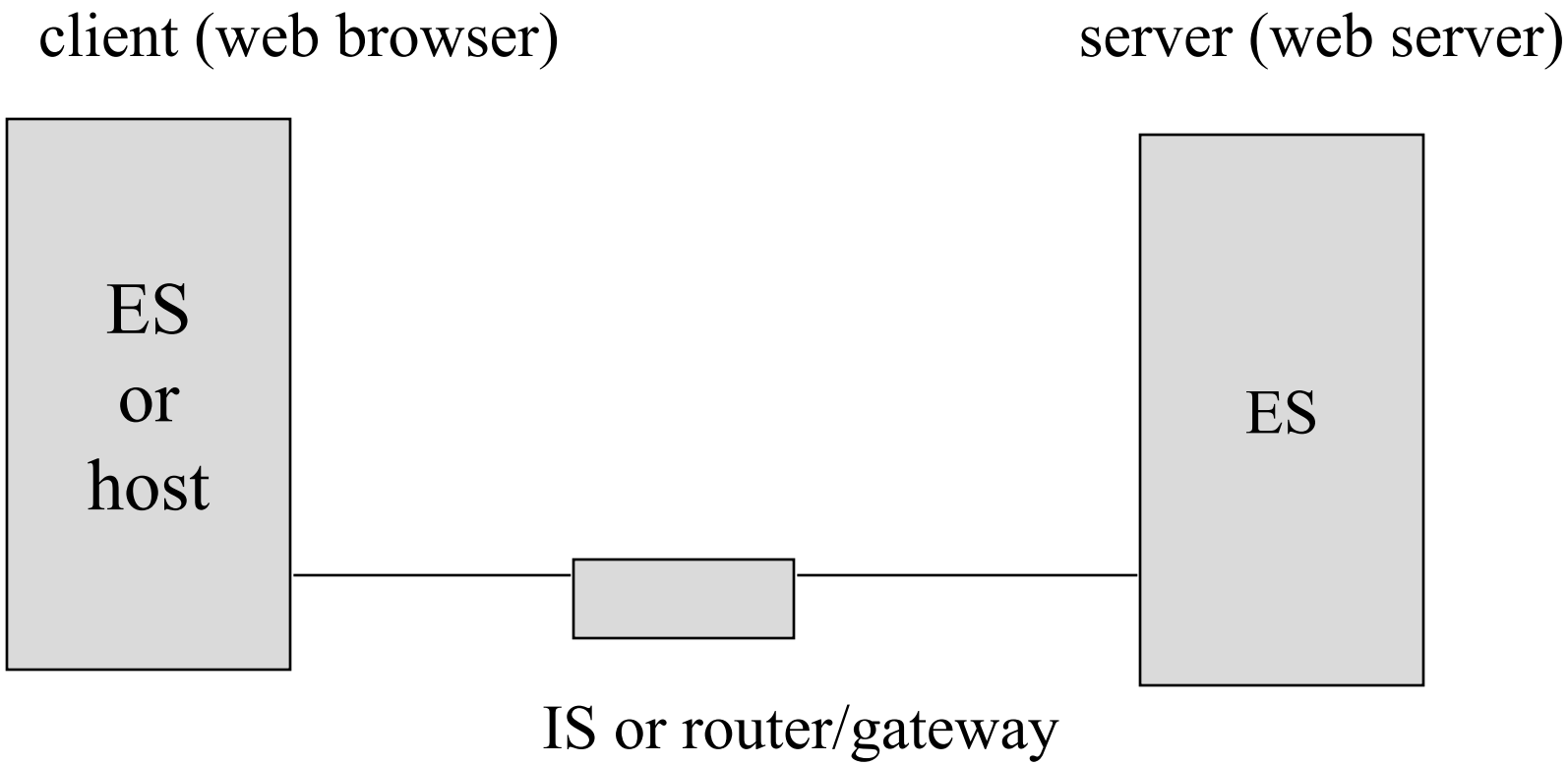
Tcp Intro

- TCP/IP - Internet protocol suite, TCP and IP are *protocols* in the suite, there are more
- open system, not proprietary, stacks from different vendors **INTEROPERATE**
  - Novell ipx, Apple appletalk - closed systems
- **Internet -** uses TCP/IP protocols
- amazingly: THERE CAN ONLY BE ONE INTERNET ...

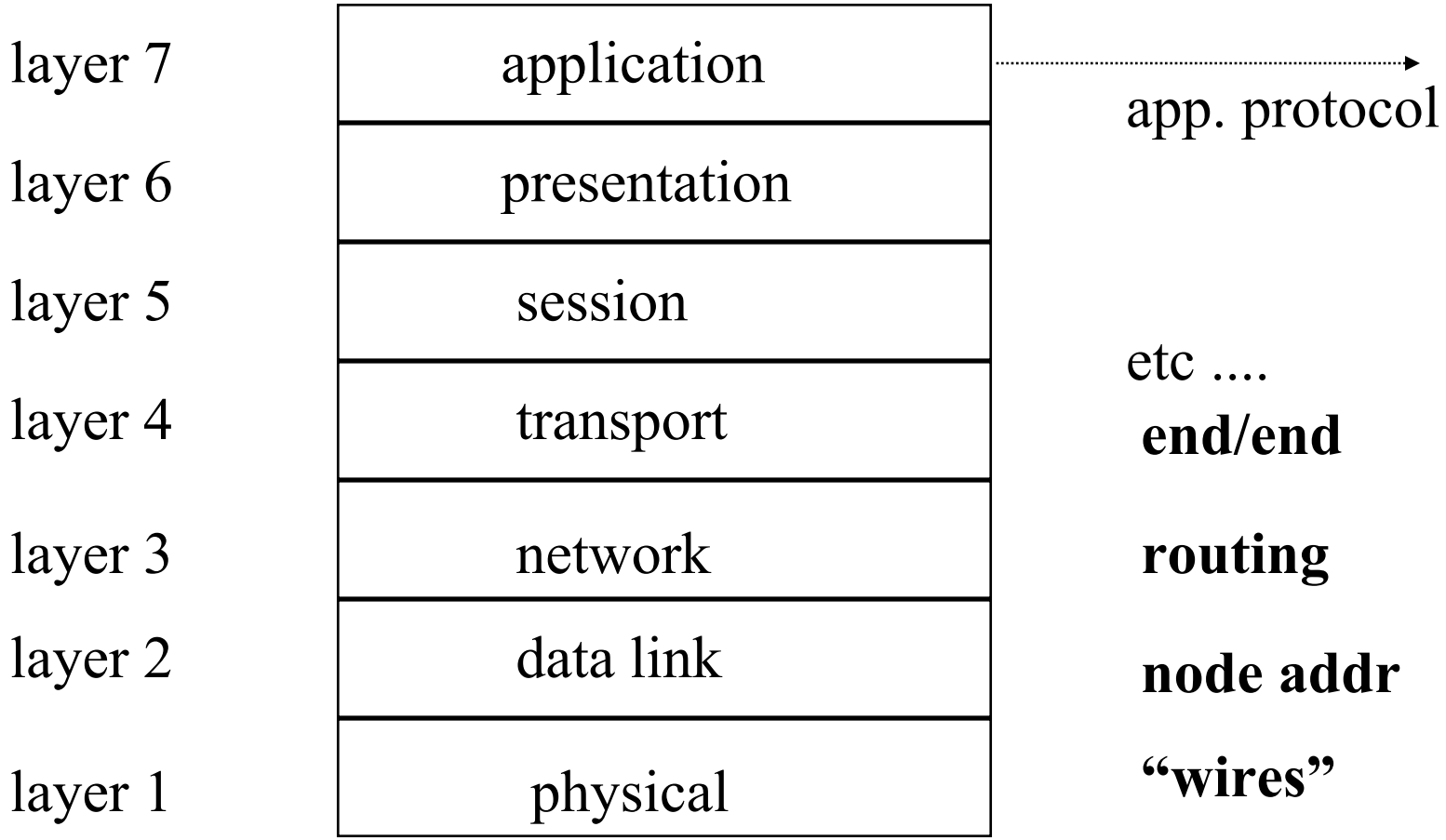
Protocol layers

- protocol layers - each layer has its own focus, associated *encapsulation* and *addressing*
- 4 layers in TCP/IP (older)
- 7 in Open Systems Interconnect (newer)
- layer is logical idea and may be in fact be ignored in implementation

end systems and intermediate systems

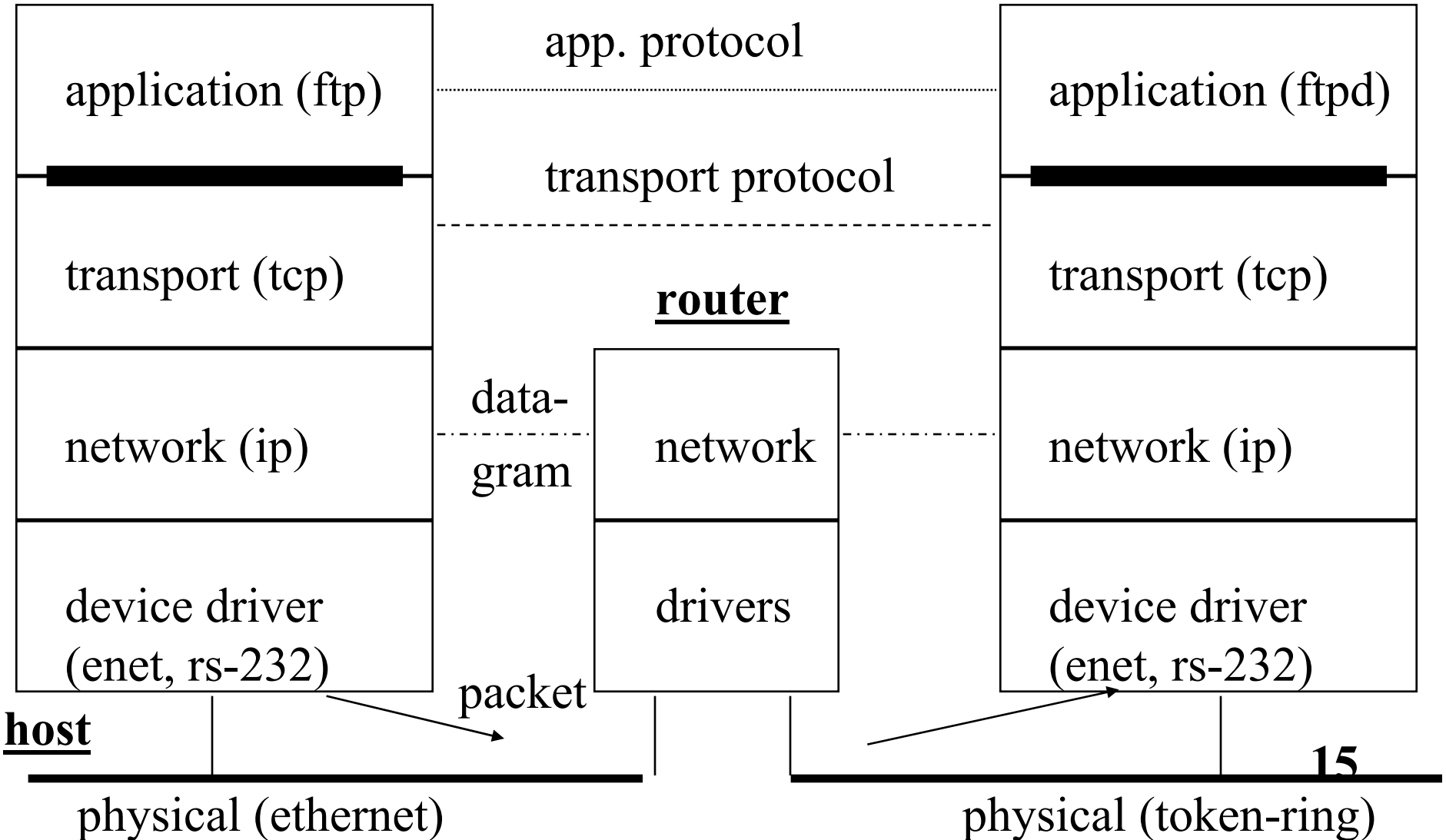


ISO/OSI Reference Model

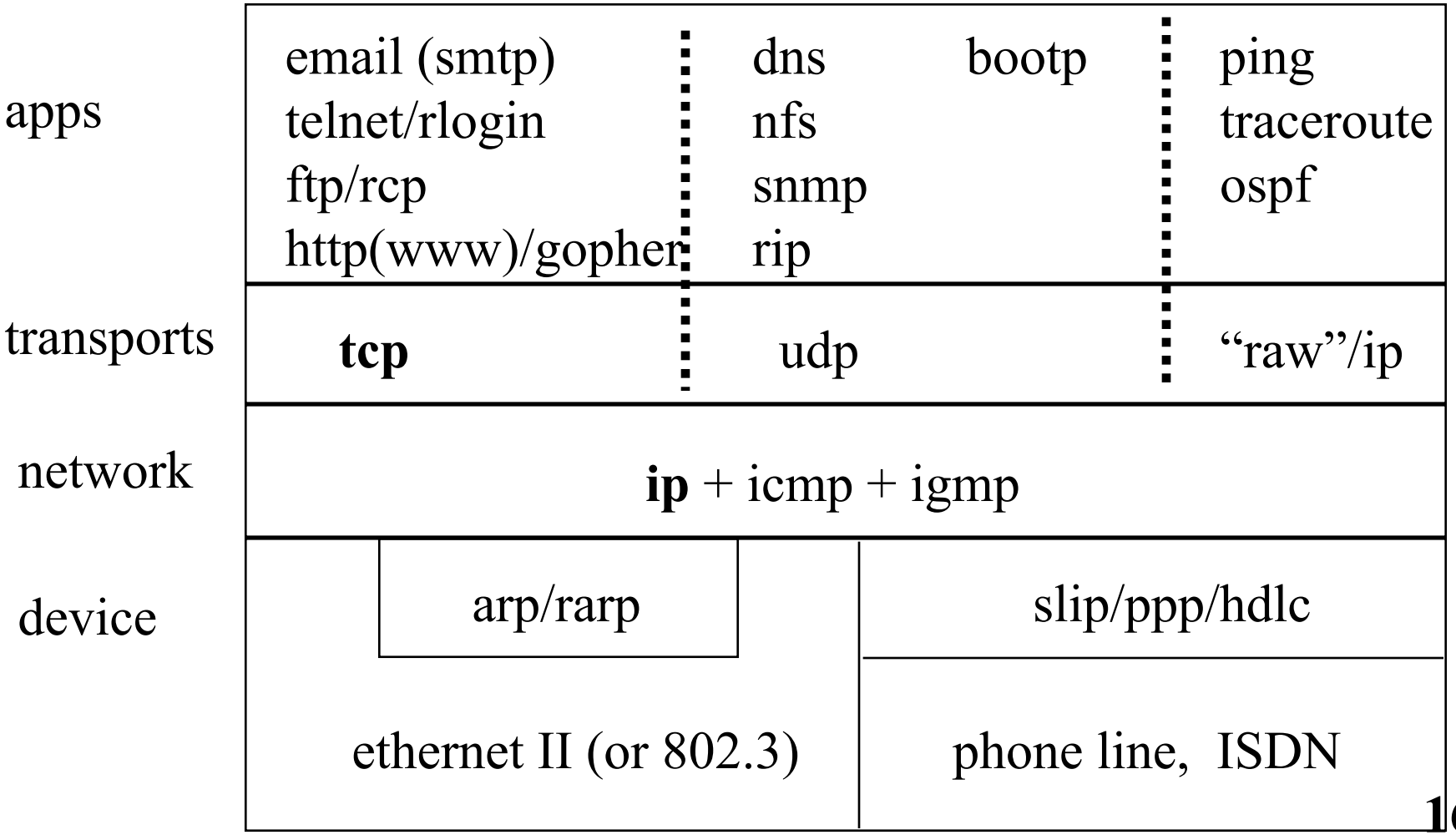


learn the numbers 1..7

TCP Layering



Internet Protocols

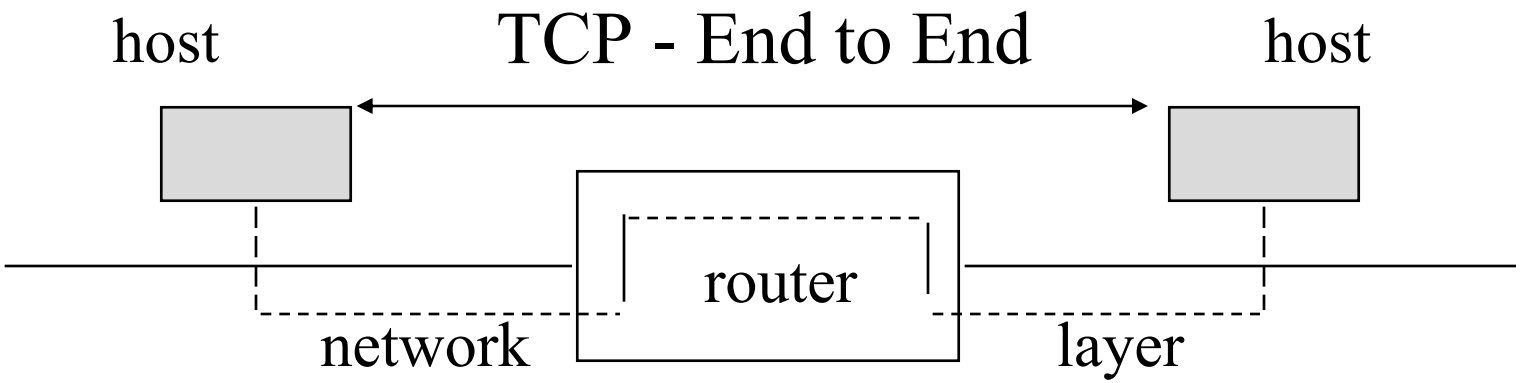


TCP layers/architecture

- data flows up/down stack
  - each layer on write adds header/addr. info. This process is called **encapsulation**
  - on read, data is **demultiplexed** - decide which protocol upstairs to feed it to, and **decapsulated**
- demux example: from link layer, packet
  - could go to IP, ARP, RARP

transport/network layer

network layer - hides physical layer
ip is hop by hop
transport layer - end to end, error correction
tcp is end to end



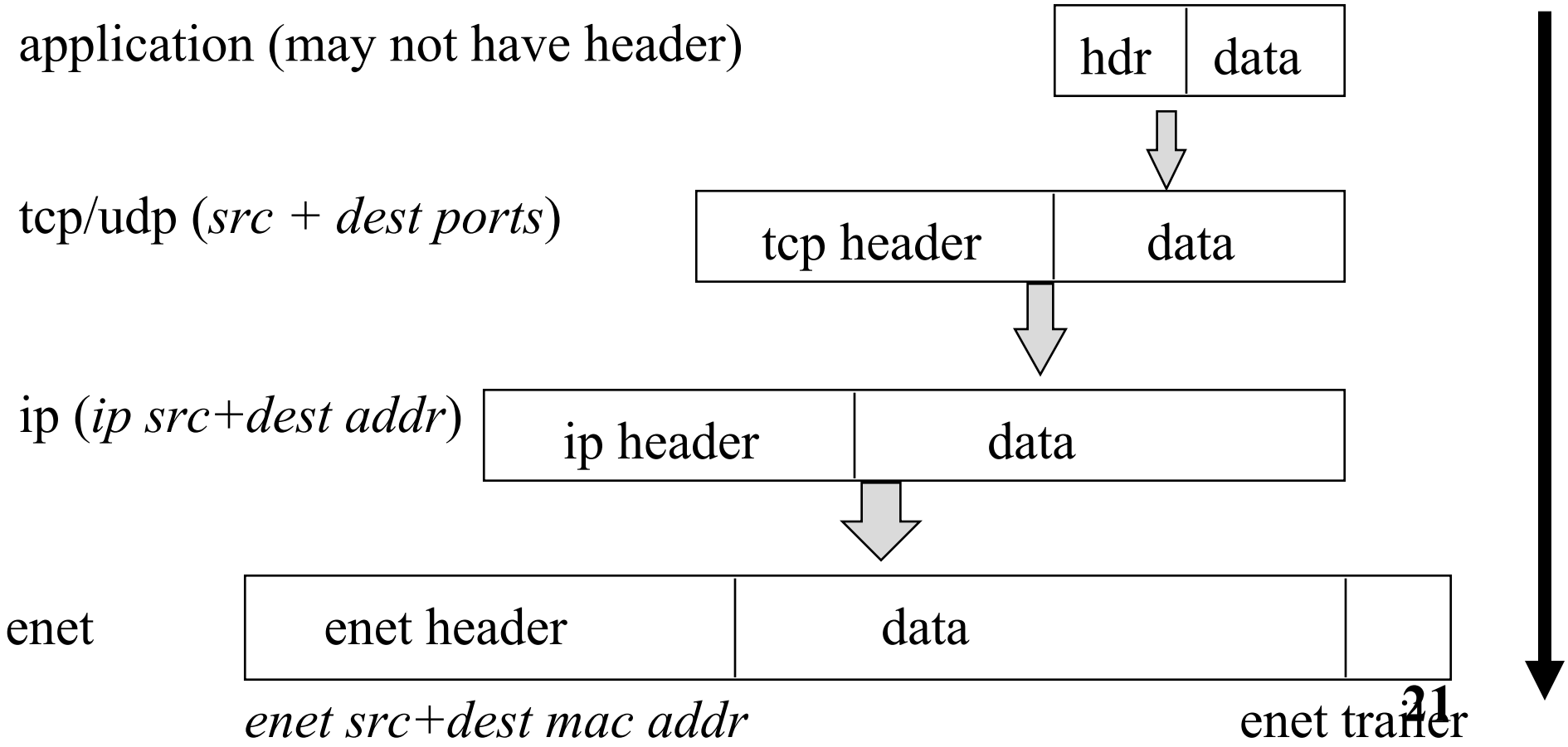
Two Big Ideas

- **peer layers in stack virtually talk to each other -- this is a "protocol"**
  - tcp talks to remote endpoint tcp
  - ftp clients talks to ftp server
  - ip src talks to ip dest and may talk to routers too
- **network layer hides transport/apps from exact details of physical layer**
  - routers glue together networks

addressing/encapsulation

- application -
  - *Domain Name System* (sirius.cs.pdx.edu)
  - sockets
- tcp/udp, use *ports*, 16 bit unsigned ints
- ip - uses *IP address*, 32 bit int
  - (net, subnet, host)
- link layer, ethernet uses IEEE 48 bit *MAC address*

encapsulation (packet goes out)



IP addresses

- per interface. each i/f has
  - (ip address, broadcast address, subnet mask)
- (network, subnet, host)
- written in *dotted decimal* in *network byte order* (big-endian)
  200.12.0.14 (0..255)
- 5 classes, A to E, each takes a bit at the hi-order end

IP class address table

class	bits	net	host	range	
class A	0	7 bits	24	0.0.0.0	127.255.255.255
class B	10	14	16	128.0	191.255.255.255
class C	110	21	8	192.0	223.255.255.255
class D	1110	28	-	224.0	239.255.255.255
class E	11110	27	-	240.0	255.255.255.255

ip addresses, cont

- 3 types of IP address (topographical)
  - unicast
    - 127.0.0.1, 201.3.4.5
  - broadcast
    - 255.255.255.255, 129.14.255.255,
    - 0.0.0.0
  - multicast
    - 225.1.2.3

ip address, cont

- uniqueness must be handled by humans
- various IP authorities at this point, **Regional Inet Registries**
- U.S. authority is ARIN (NA, SA, Africa), www.arin.net
  - APNIC for asia, RIPE for europe (there are more now)
- ISP feeding chain in U.S., ends up at ARIN
- IP (v4,v6) addresses + A.S. numbers (later)
- DNS was from Internic: rs.internic.net, Network Solutions (www.networksolutions.com), ICANN (www.icann.org)
  - now broken up into separate registration companies

whois

- traditional tool for looking up
  - 1. dns names
  - 2. ip address info
- e.g.,
  - % whois pdx.edu
  - % whois -h whois.arin.net 131.252.0.0/16
  - web: www.internic.net/whois.html
- go and play with these ...

obtaining an IP address

- you used to get it from the Internic, but now usually from IP/pipe “ISP”
- we need to worry about making sure that addresses can be **hierarchical**
  - CIDR blocks, allocated top-down from your “provider” to you
  - if you change providers, you get to renumber
  - ip addresses dynamic or static
    - » dynamic means using DHCP
    - » static means manually configured

transport/port numbers

- TCP/UDP unsigned 16-bits shorts
  - 0..64k-1
- servers are known by “well-known” ports
  - e.g., telnet 23, http 80, ftp 20, mail 25
- IAssigned Numbers Authority (IANA) assigns them
  - www.iana.org, also see www.icann.org
- on UNIX stored imperfectly in
  - */etc/services*
- UNIX reserves ports 0..1023 for “root”/su-only
- dynamically viewed with *% netstat -a*

Domain Name Systems

- primary function - map human readable names to IP numbers
  - sirius.cs.pdx.edu -> 131.252.220.13
- done entirely as application on top of UDP
- client-server model, with DNS servers in relatively flat hierarchy
- **o.s. deals in ip addresses, not DNS names**

client - server paradigm

- applications (and sometimes o.s.) organized in application architecture paradigm called *client-server*
- usually but not always message oriented
- client app talks app. protocol to remote server that processes each message
- servers might be
  - **iterative** (process message to conclusion) / UDP
  - or **concurrent** (**master/slave**) / TCP

client-server, server forms:

- iterative:

```
do forever
        wait/read client message
        process message
        write ACK to client
```

- concurrent

```
do forever
        wait for connection
        fork (spawn task)
                child does i/o and exits
```

Internet - what is it?

- elephant and blind men ... many Points of View
- a suite of many app protocols on top of TCP/UDP/IP - open system, etc., etc.
  - packet switched net on top of circuit/telco
- on MANY physical networks, WAN/LAN
- the World Wide Web (http/TCP)
  - or chat rooms?
- a computer network that can survive atomic attack?
  - but where network security is an oxymoron?

Internet - what is it?

- *Internet* - the world-wide set of nets combined with TCP/IP
- *internet* - a bunch of nets tied together
- The Internet is built on TOP of the phone co's net and views the TELCO network as a link layer black box (**subnet model** as opposed to **peer model**)

physically?

- 10+ Network Access Points or NAPs/MAEs
  - where backbones meet
- N backbones that cross the U.S.
  - UUNET/PSI/GTE(BBN Planet)/Sprint/C&W
  - T3, or faster OC3/OC12/OCfast ATM/SONET
- regionals (being purchased by the above)
- local (and national) ISPs
  - AOL/teleport/raindrop labs
- Jane User with her pc/56k modem

telco WAN technologies

- ATM/SONET (maybe) OC3 (155), OC12 (655)...
  - OC48 or faster possible (WDM means virtual pipes)
- T3 (<45Mbps) - STM - $25k/month
- T1 (1.54Mbps) - $500 - $2k/month
- frame relay (shared load)
- ADSL - new, cable modem, 256-T1 or so
- ISDN 64/128k
- analog modems (POTS) 56k/28.8k/14.4k
- ETHERNET is starting to make a dent at least in MANs (1 gigabit, 10 gigabit soon)

ISPs - Internet Service Provider

- provides you with a connection + X services
- services might include:
  - a wire, however big/small
  - ip address space (or an ip network for N lan machines) + DNS name/server, ppp (routing)
  - SMTP email (POP accounts)
  - UNIX login account
  - NNTP Usenix news
  - web pages or ... servers or “e-commerce”

who controls it?

- Internet is world-wide - question of govt. control is very interesting
  - governments versus Internet
  - Inet said to “route around censorship”
    - » John Gilmore: www.eff.org
- IAB/IETF determine standards
- but industry may preemptively determine standards (early bird ...)

  Oracle/Microsoft/Sun/Intel/Cisco

Internet Organization (well...)

- ISOC - Internet Society. professional society to faciliate, support, promote Inet
- IAB - technical oversight and coordination, falls under ISOC
- IESG - Inet Eng. Steering Group oversees:
- IETF - meets 3 times a year, develops, argues over, and standardizes protocols for Inet. 70-80 wgs. Organized in areas, e.g., routing area.
- IRTF - Internet Research Task Force - long term research, just a few people compared to IETF

Standards Process

- standards called RFCs - Requests For Comment
- numbers > 3900 now
- IETF wg members write “drafts”, eventually hopefully may become standards
- not all protocols have RFCs. not all RFCS are actually used
- *www.rfc-editor.org*

TCP/IP free “stack” implementations

- “stack” == o.s. part, not the apps
- de facto source standard is BSD, now 4.4
  - 4.2 BSD 83 - first widely spread tcp/ip
  - 4.3 BSD 86 - perf. improvements
  - 4.3 BSD Tahoe 88 - slow start, congestion avoidance
  - 4.3 BSD Reno 90 - tcp header prediction, slip header compression, new router algorithm
  - 4.4 BSD 93, multicasting
- others: KA9Q for dos; linux (unix)
- 4.4 BSD book, Steven’s volume 2 (freebsd)
- **reference implementations:** bsd tcp/ip, apache, bind, mrouted, zebra, etc ...