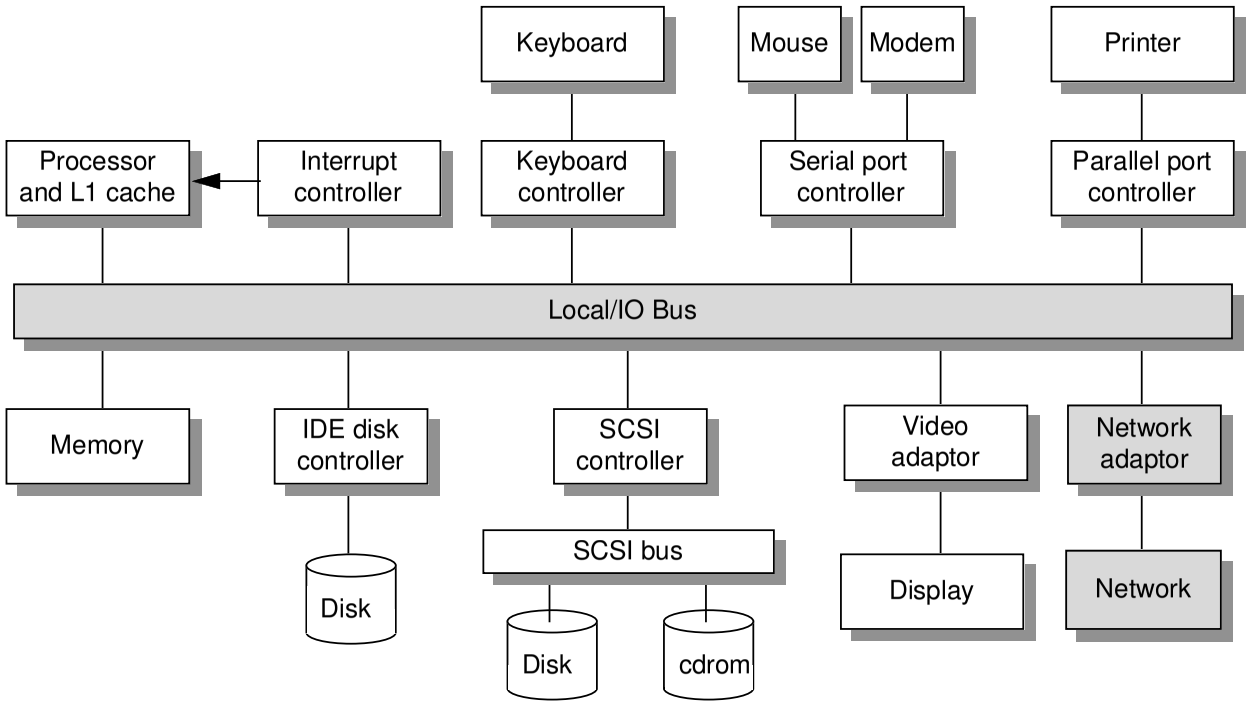
Networks

April 22, 1996

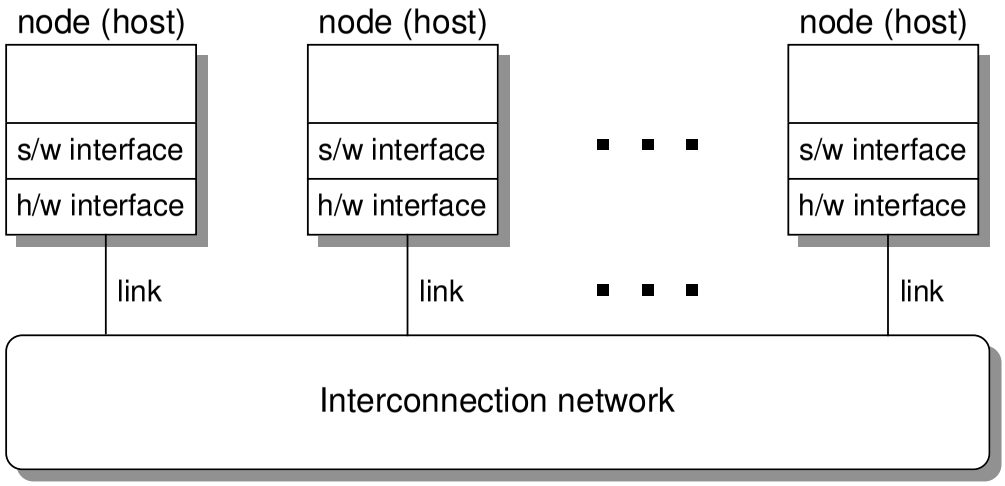
Topics:

- **Ethernet**
- **ATM**
- **internetworks**

Computer system



Generic interconnection network



Basic network types

Massively parallel processor network (MPP)

- **same room (10's of meters)**

Local area network (LAN)

- **same building or campus (kilometers)**

Metropolitan area network (MAN)

- **same city (10's of kilometers)**

Wide area network (WAN)

- **nationwide or worldwide (1000's of kilometers)**

Internetworks

- **interconnected networks**
- **same room or worldwide**

Basic network issues

addressing

- messages must be directed to a particular process on a particular host

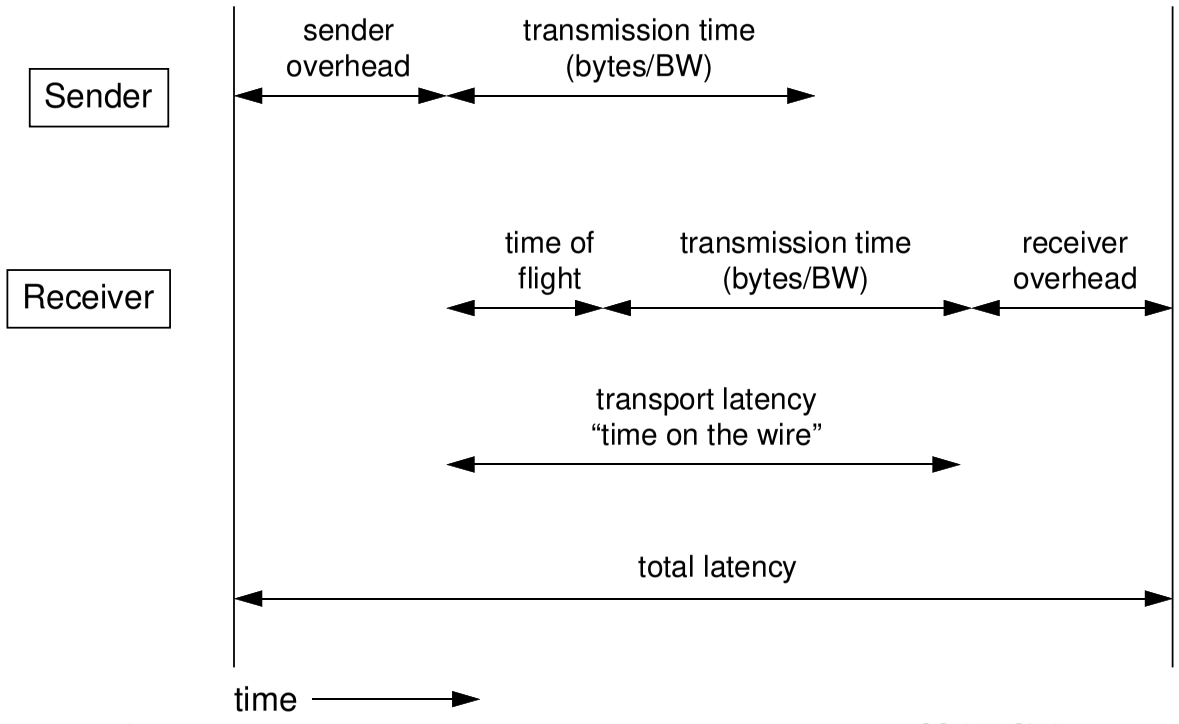
reliable delivery

- messages are not lost
- messages are not garbled

efficient delivery

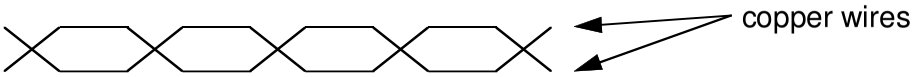
- data transfer is overhead to applications
- capacity measured as bandwidth (throughput) BW = Mbits/sec

Network performance metrics

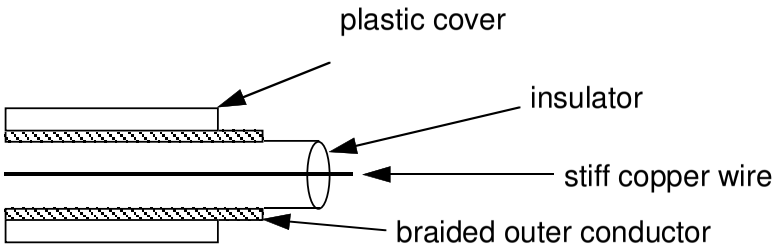


Network media

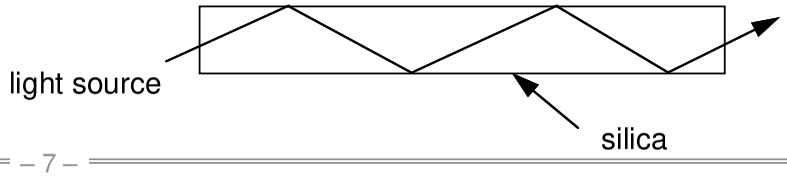
twisted pair:



twisted pair:

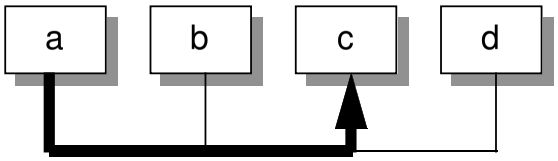


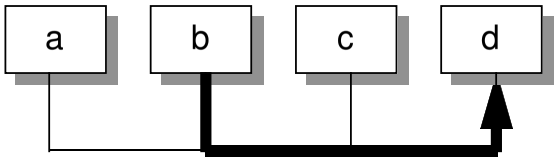
fiber:



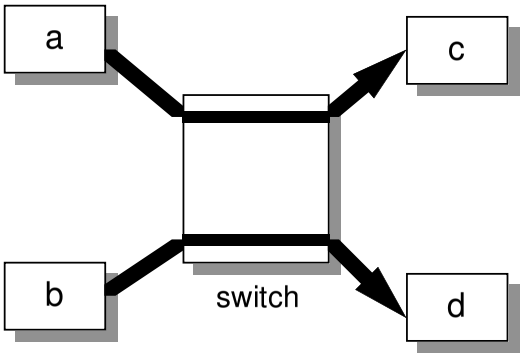
Shared vs switched media

Shared media (Ethernet)





Switched media (ATM)



Ethernet

History

- **1976- proposed by Metcalfe and Boggs at Xerox PARC**
- **1978 - standardized by Xerox, Intel, DEC**

Bandwidth

- **10 Mbits/sec (old) , 100 Mbits/sec (new)**

Key features

- **broadcast over shared bus (the ether)**
  - no centralized bus arbiter
  - each adapter sees all bits
- **each adapter has a unique 48-bit address**
- **variable length frames (packets) (64 - 1518 bytes)**

Ethernet frame format

64 - 1518 bytes

Preamble	**Dest addr**	**Src addr**	**Frame type**	**Payload**	**CRC**
64 bits	48 bits	48 bits	16 bits	368-12000 bits	32 bits

Preamble: 101010101 (synch)

dest and src addr: unique ethernet addresses

payload: data

CRC: cyclic redundancy check (error detection)

Binary exponential backoff protocol

Sender:

- **wait until no adapters are transmitting**
- **transmit frame**
- **while transmitting, listen for interference (i.e. a collision)**
- **if collision, wait rand() seconds and try again.**
- **if collision again, wait 2*rand() seconds and try again.**
- **if collision again, wait 4*rand() seconds and try again.**
- **... and so on**

Receiver:

- **adapter receives each frame**
- **if address doesn't match: ignore**
- **if address matches: external interrupt**

Ethernet pros and cons

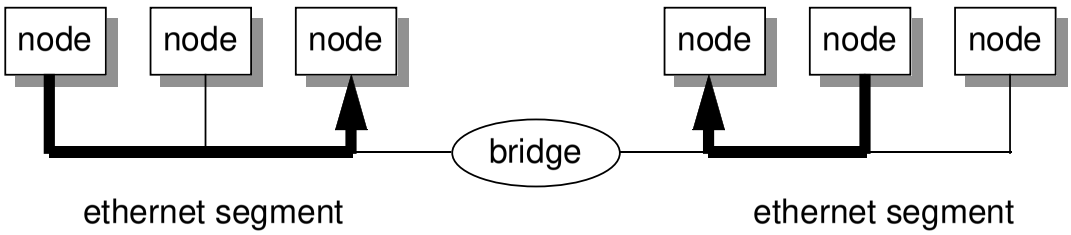
Pros:

- **simple**
- **robust**
- **cheap ($50/adapter in 1996)**

Cons:

- **no quality of service guarantees**
  - OK for data
  - not OK for real-time bit streams like video or voice
- **fixed bit rate**
  - not keeping up with faster processors
  - workstation can produce data at 10-50 MBytes/sec
- **prone to congestion**
  - processors getting faster
  - bridged Ethernets can help some

Bridged Ethernet



Asynchronous transfer mode (ATM)

History

- **1988- proposed by international ATM forum**
- **telecomunications and computer vendors**

Goal:

- **mechanism for integrated transport of bit streams with different performance and reliability requirements (quality of service)**
  - video: 1.5 Mbits/sec, latency and variance sensitive, some bit loss OK
  - voice: 64 Kbits/sec, latency and variance sensitive, some bit loss OK
  - data: high data rates, latency and variance insensitive, bit loss not OK

ATM overview (cont)

Bandwidths

- **OC-1: 51.84 Mbits/sec**
- **OC-3: 155.52 Mbits/sec (current LAN rate)**
- **OC-12: 622.08 Mbits/sec (current LAN rate)**
- **OC-24: 1244.16 (Gigabit network)**

Key features:

- **virtual connections (VC's)**
  - allow bandwidth reservation
- **fixed cell (frame) size**
  - simplifies high-speed switching
- **small cell size**
  - allows fine-grained allocation of network bandwidth

ATM cell format

53 bytes (fixed)

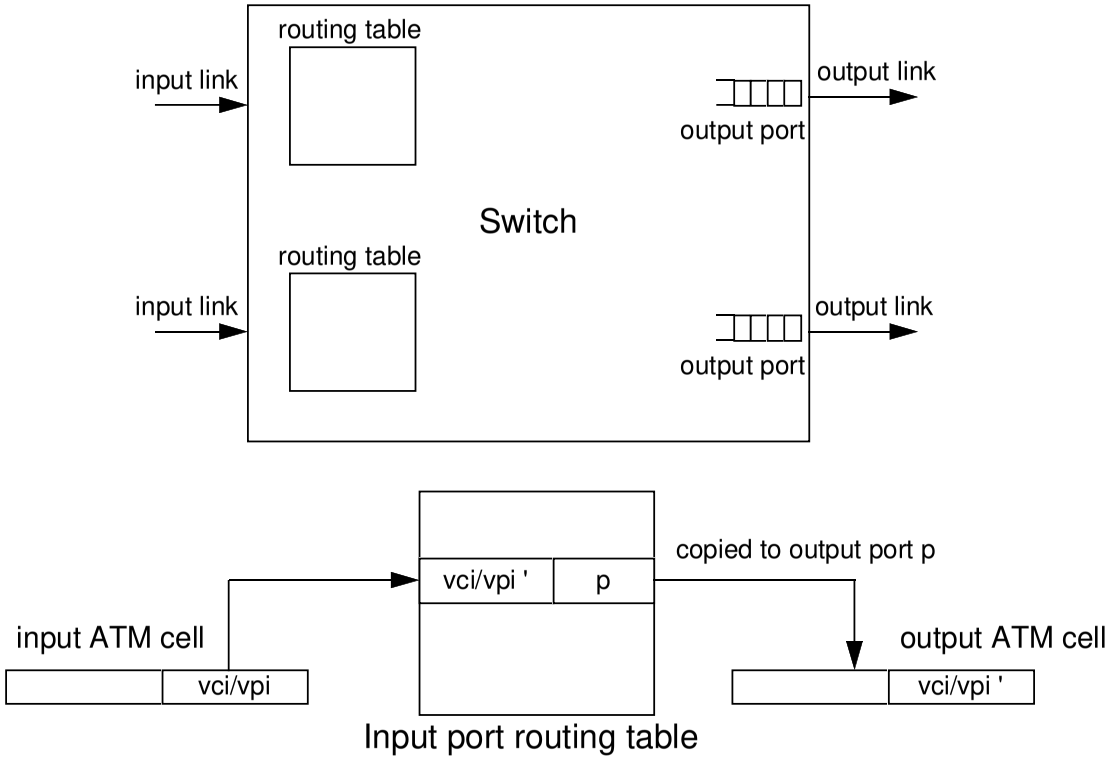
Generic flow ctl	**VCI/ VPI**	**Payload type**	**Priority**	**Header checksum**	**Payload**
4 bits	24 bits	2 bits	2 bits	8 bits	48 bytes

VCI: virtual connection (channel, circuit) identifier

VPI: virtual path identifier

payload: data

ATM cell routing



ATM pros and cons

Pros:

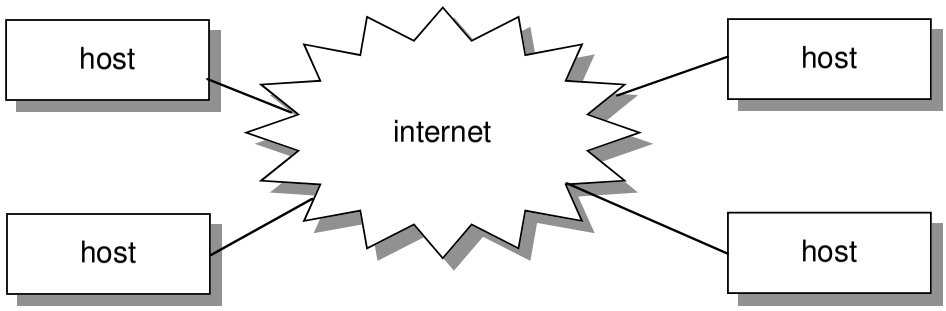
- **bandwidth can be reserved (connections)**
- **scalable aggragate bandwidth (wide range of supported bit rates)**
- **support for network traffic with different quality of service requirements (small, fixed, easily multiplexed cells)**
- **potential for high speed switching (small fixed-size cells)**

Cons:

- **maximum user bandwidth still limited by link bandwidth**
- **connections make broadcast and multicast more difficult**
- **quality of service is still a research issue**

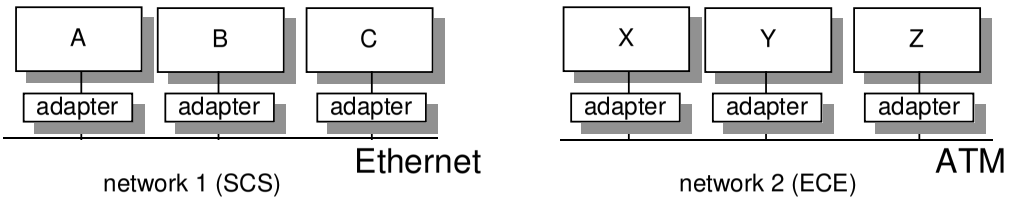
Internetworks

Def: An *internetwork* (internet for short) is an interconnected collection of networks



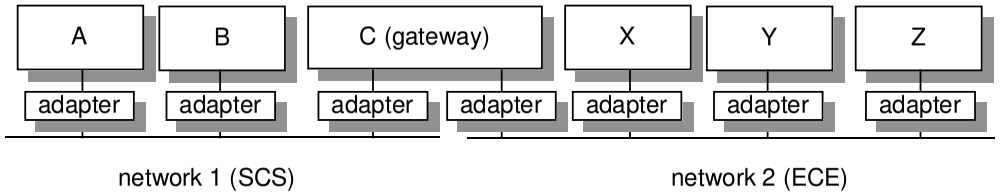
Building an internet

We start with two separate, unconnected computer networks, which are at different locations, and built by different vendors



Building an internet (cont)

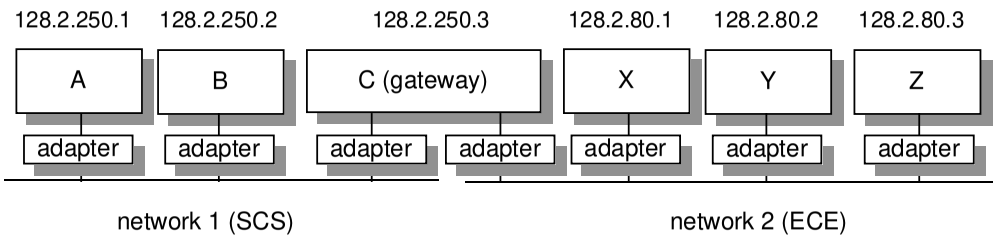
Next we connect one of the computers
(in this case computer C) to each of the networks.



Building an internet (cont)

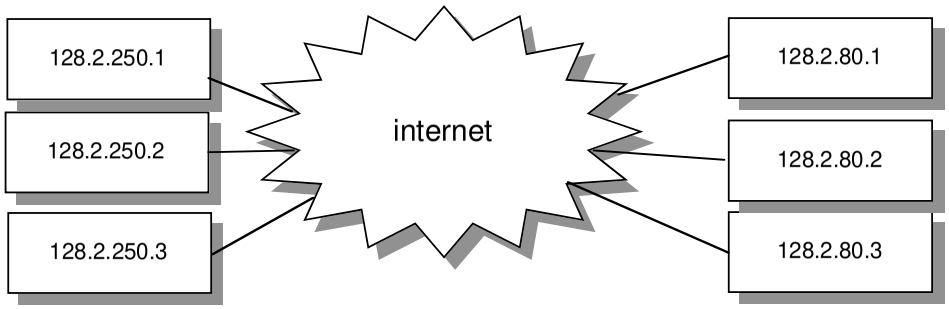
Finally, we run a software program called Internet Protocol (IP)
on each computer. IP maps hardware address to unique 32-bit
IP addresses and routes messages between network1 to network 2
if necessary.

IP addresses:

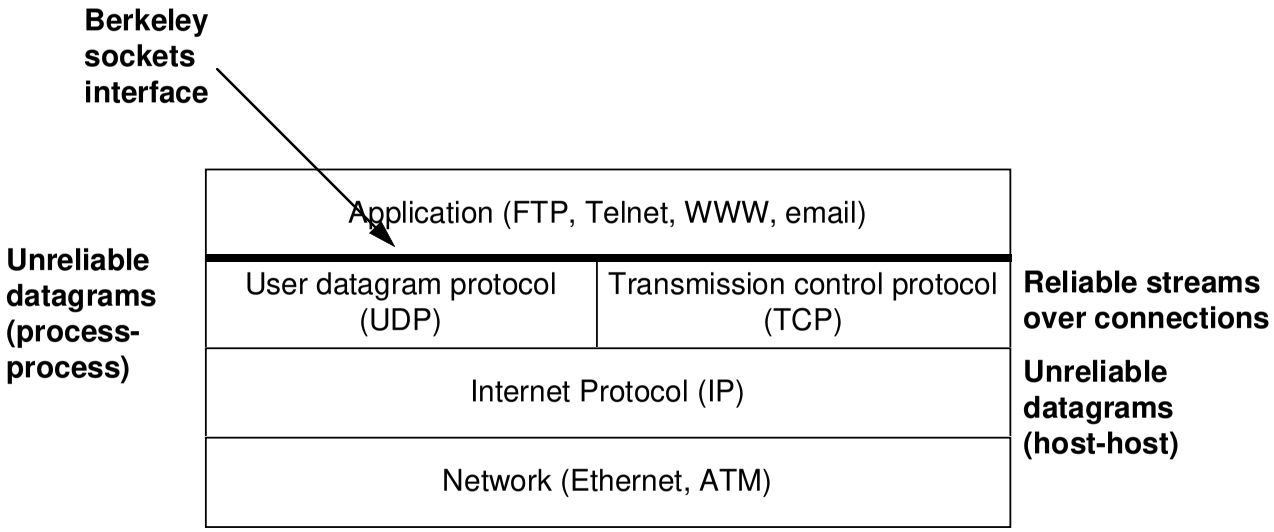


Building an internet (cont)

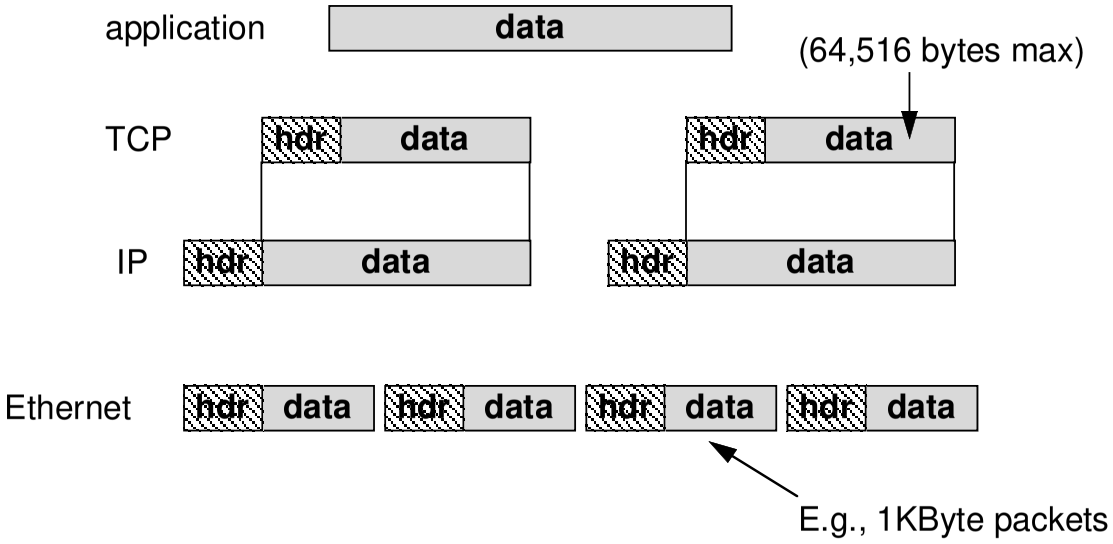
At this point we have an internet consisting of 6 computers built from 2 original networks. Each computer on our internet can communicate with any other computer. IP provides the illusion that there is just one network.



Internet protocol hierarchy (stack)

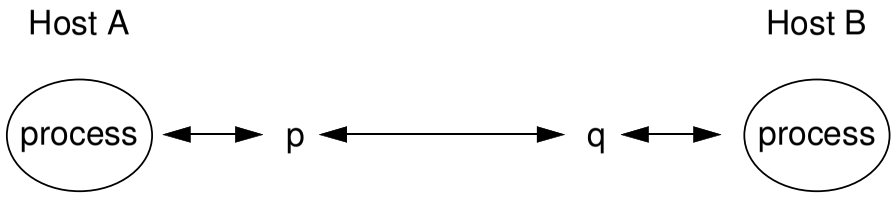


Encapsulation



TCP programming model

(1) Create a bidirectional connection between (host A, port p) and (host B, port q)



(2) Transfer data streams over connection

(3) close connection