Spinning the World Wide Web

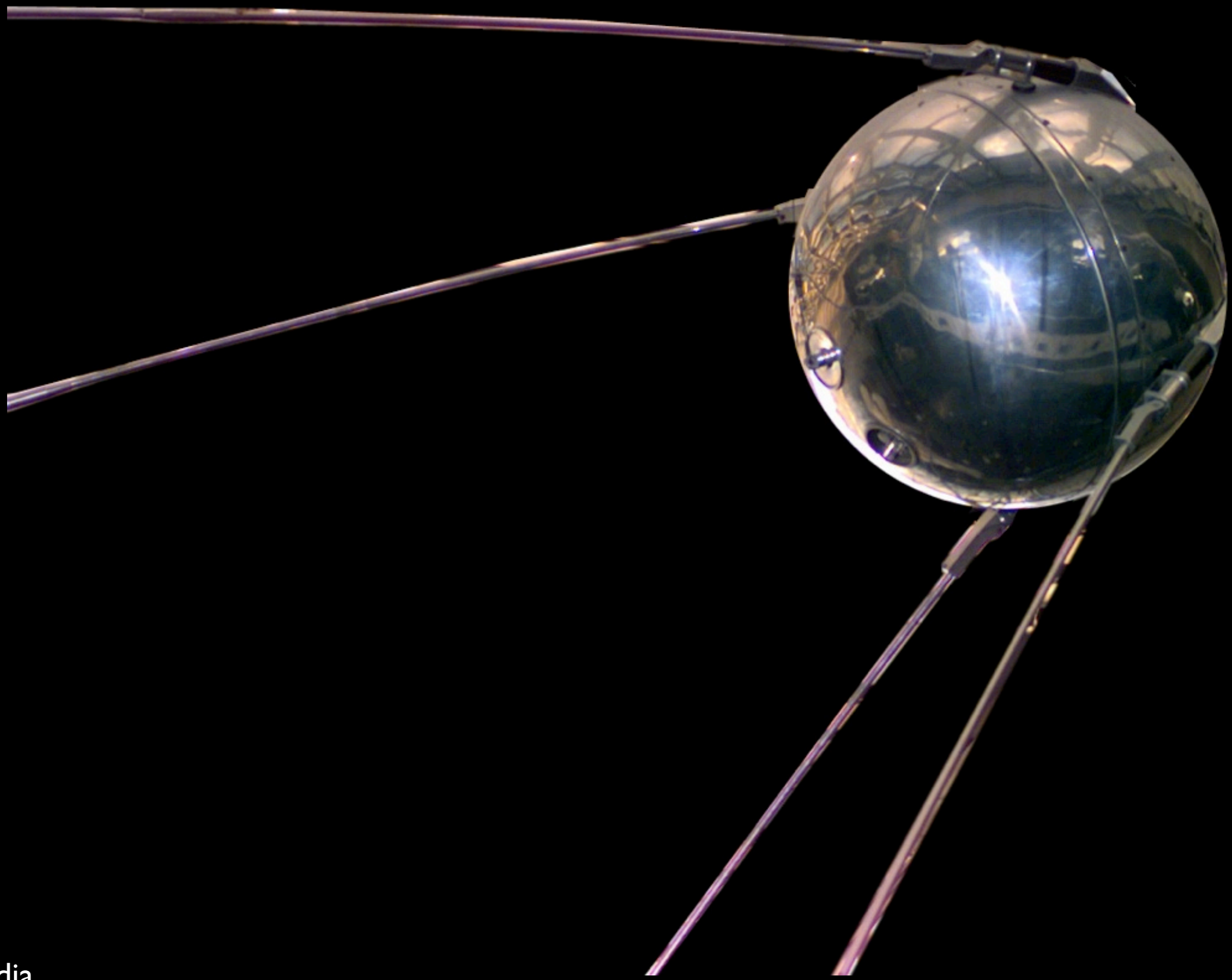
How the Internet really works

Prof. Mark L. Chang, Olin College

First, your questions

How do you
use the Internet?

In the beginning...

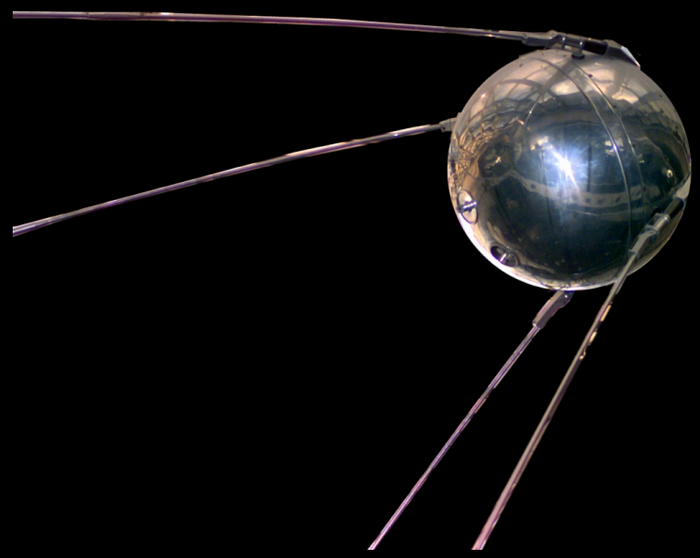


wikipedia

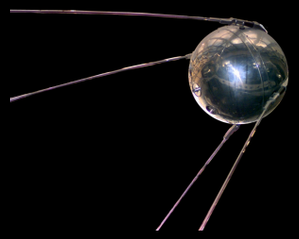
wikipedia

1957

USSR launches Sputnik



wikipedia

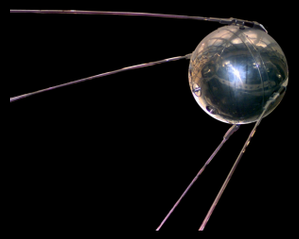


1957

February 1958

US creates ARPA to advance science and technology for the military

wikipedia



ARPA

1957

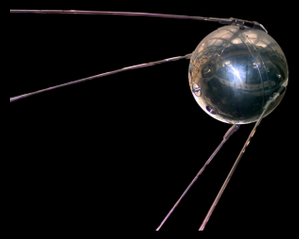
1958

lroberts.us

August 1962

J. C. R. Licklider (of BBN) publishes memos about a “Galactic Network” connecting people and computers. He gets hired.

wikipedia



ARPA

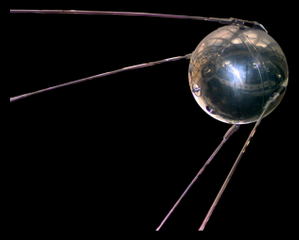
1957

1958

lroberts.us

Larry Roberts (of MIT Lincoln Labs) hired by ARPA and tasked with creating this computer network

wikipedia



ARPA

Galactic Network

1957

1958

1962

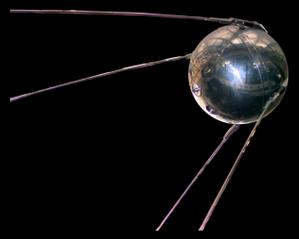
UCLA

SRI

January 14, 1969

Completed the first link between UCLA and Stanford Research Institute

wikipedia



ARPA

Galactic Network

1957

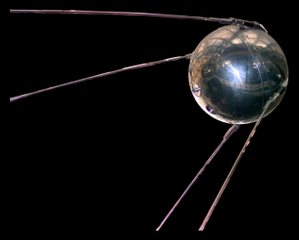
1958

1962

October 29, 1969, 10:30 PM

First message sent over the network

wikipedia



ARPA

Galactic Network

1957

1958

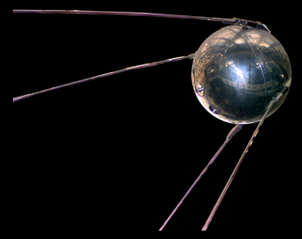
1962

October 29, 1969, 10:30 PM

The message:

`Login`

wikipedia



ARPA

Galactic Network

1957

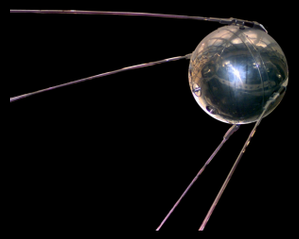
1958

1962

October 29, 1969, 10:30 PM

Well, almost...

wikipedia



ARPA

Galactic Network

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1958

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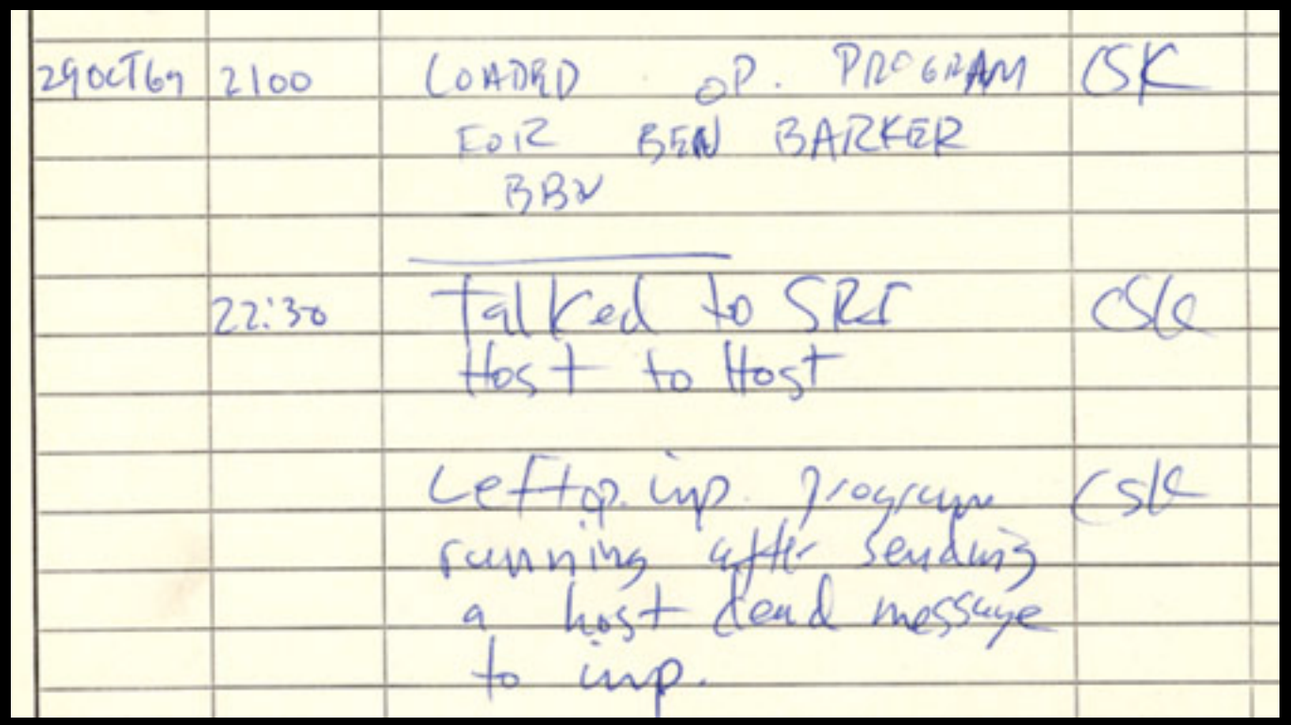


29OCT69 2100 LOADED OP. PROGRAM (SK
FOR BEN BARKER
BBN

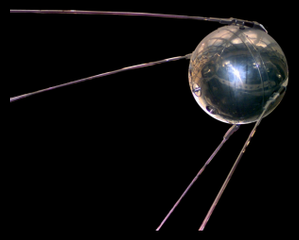
22:30 Talked to SRI (SK
Host to Host

Left op. imp. program (SK
running after sending
a host dead message
to imp.

The written log of that event

CSK ==
Charles S. Kline

wikipedia



ARPA

Galactic Network

1957

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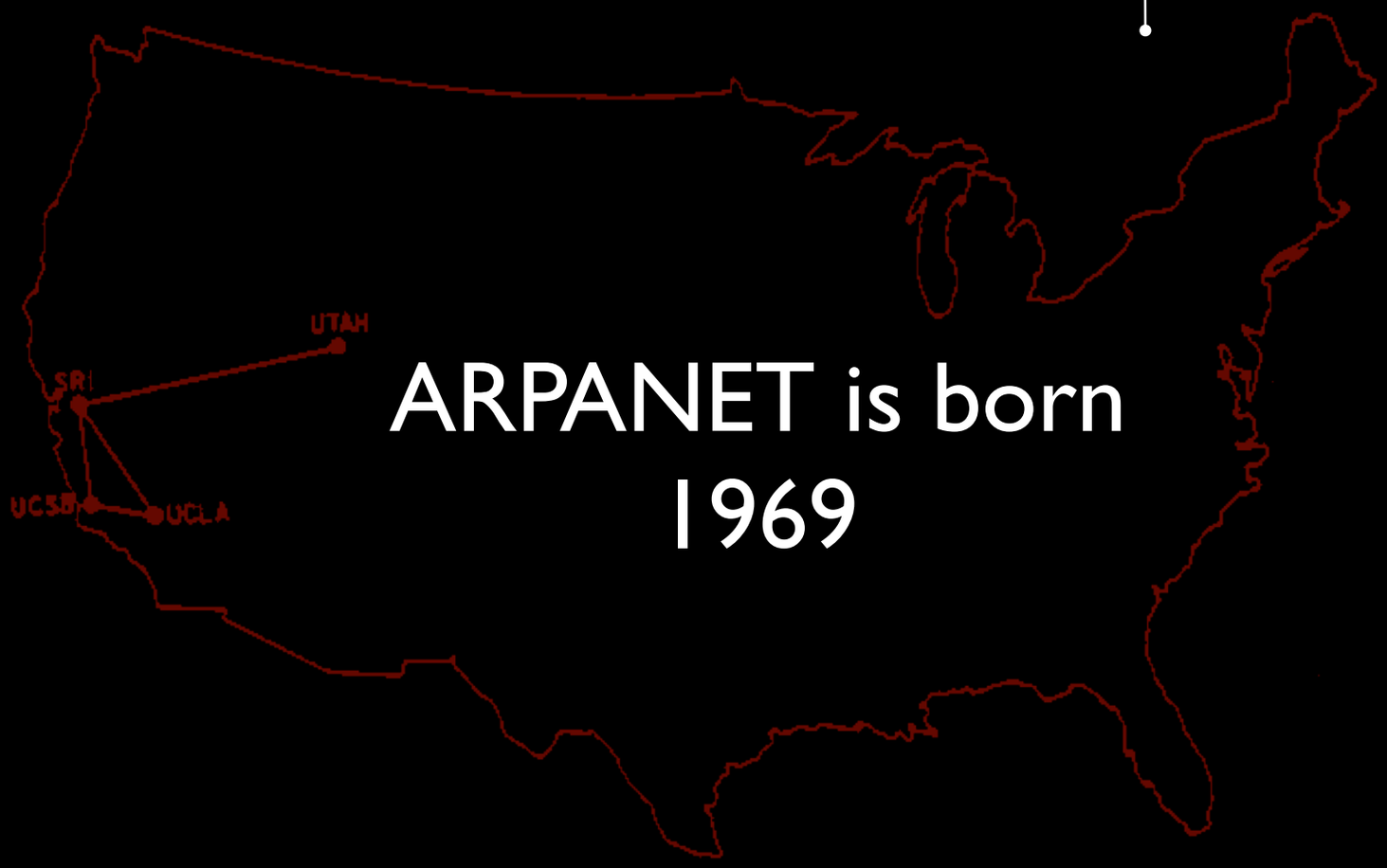
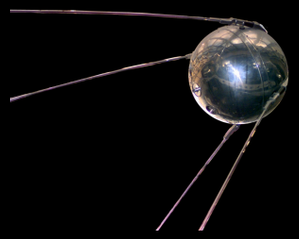


ARPANET is born 1969

http://som.csudh.edu/cis/lpress/history/arpamaps/



ARPA

Galactic Network

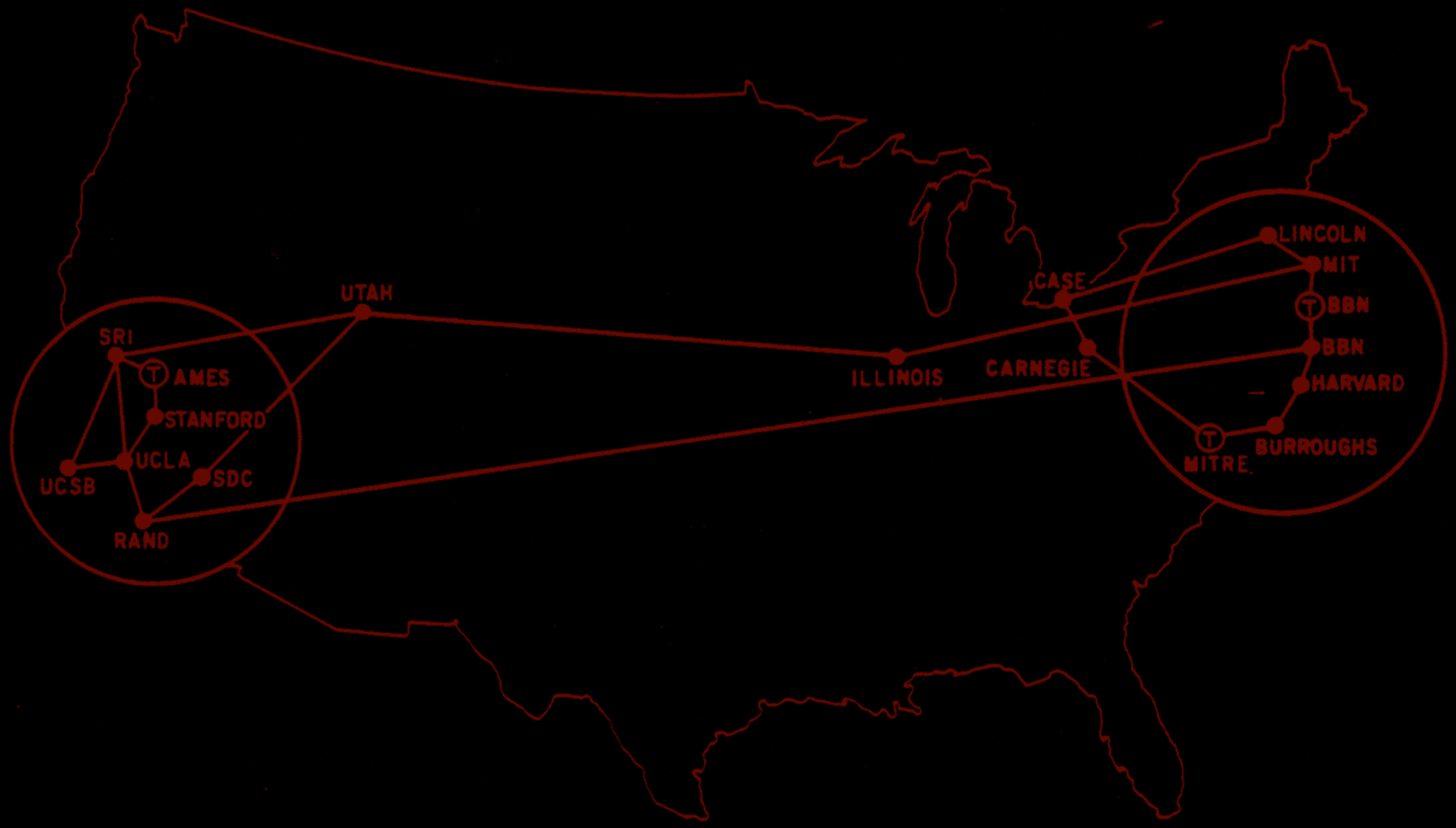
ARPANET

1957

1958

1962

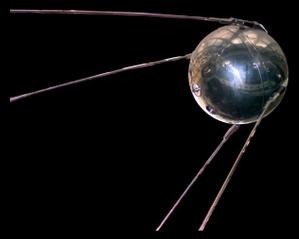
1969



1971

ARPANET
network map

http://som.csudh.edu/cis/lpress/history/arpamaps/



ARPA

Galactic Network

ARPANET

1957

1958

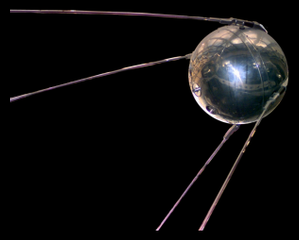
1962

1969

1971

Ray Tomlinson (BBN) sends the first email

wikipedia



ARPA

Galactic Network

ARPANET

1957

1958

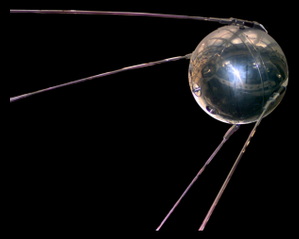
1962

1969

1971

Between two machines sitting next to each other

http://openmap.bbn.com/~tomlinso/ray/ka10.html



ARPA

Galactic Network

ARPANET

1957

1958

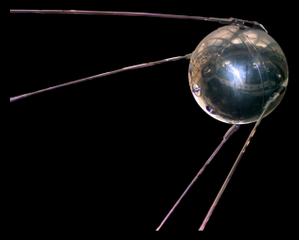
1962

1969

1971

And essentially invents the use of the @ symbol for email

http://openmap.bbn.com/~tomlinso/ray/ka10.html



ARPA

Galactic Network

ARPANET

1957

1958

1962

1969

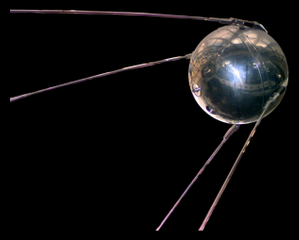
1971

"Most likely the first message was QWERTYUIOP or something similar."

{Ray Tomlinson}

Ray can't remember what he wrote.

http://openmap.bbn.com/~tomlinso/ray/ka10.html



ARPA

Galactic Network

ARPANET

First Email

1957

1958

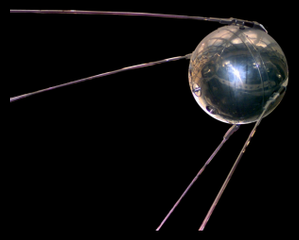
1962

1969

1971

ARPANET keeps growing

wikipedia



ARPA

Galactic Network

ARPANET

First Email

1957

1958

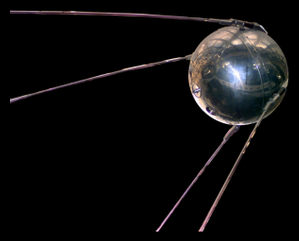
1962

1969

1971

NSF networks universities together (NSFNET)
NSFNET connects to commercial networks in 1988

wikipedia



ARPA

Galactic Network

ARPANET

First Email

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1958

1962

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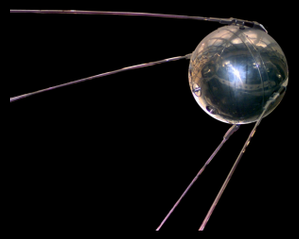
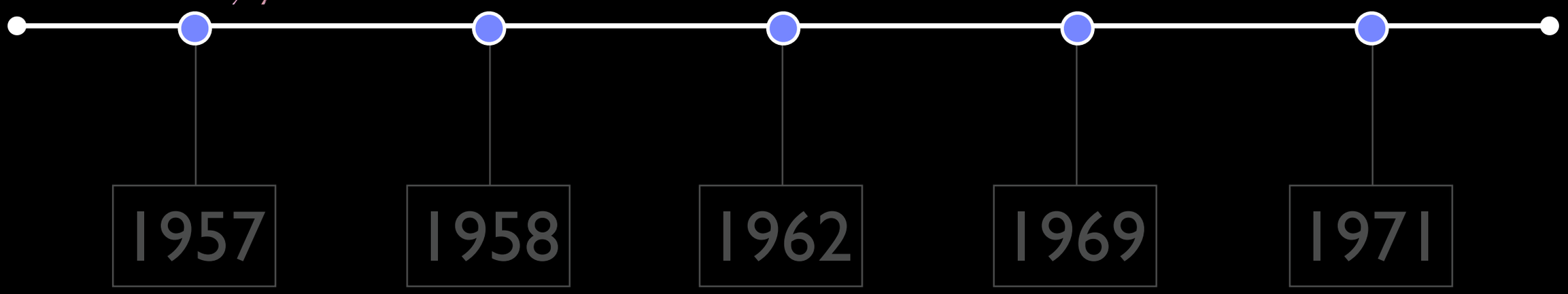
1971

US Military creates MILNET
and shuts down ARPANET in 1989

NSFNET is decommissioned April 30, 1995

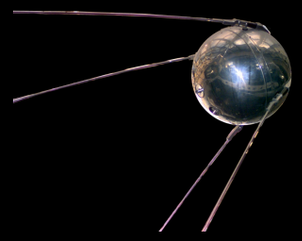
wikipedia





The Internet is now entirely commercially owned and operated

wikipedia



ARPA

Galactic Network

ARPANET

First Email

1957

1958

1962

1969

1971

August 6, 1991

CERN publicizes the World Wide Web
created by
Tim Berners-Lee

wikipedia

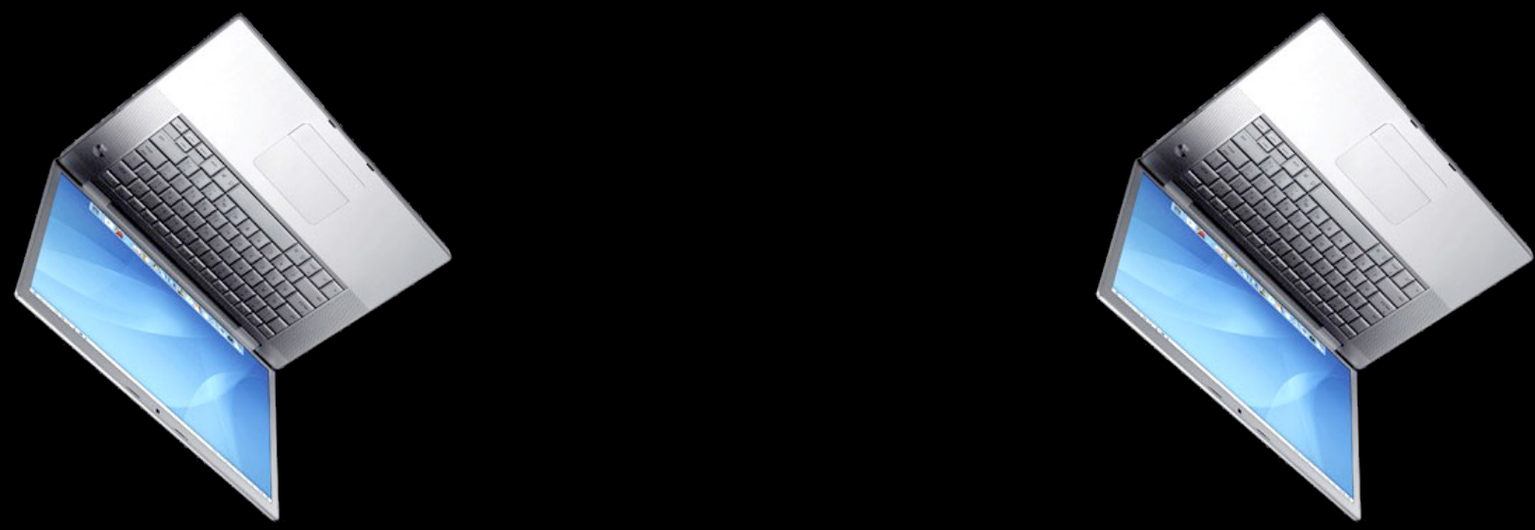
http://www.w3.org/History/19921103-hypertext/hypertext/WWW/TheProject.html

Today's Internet

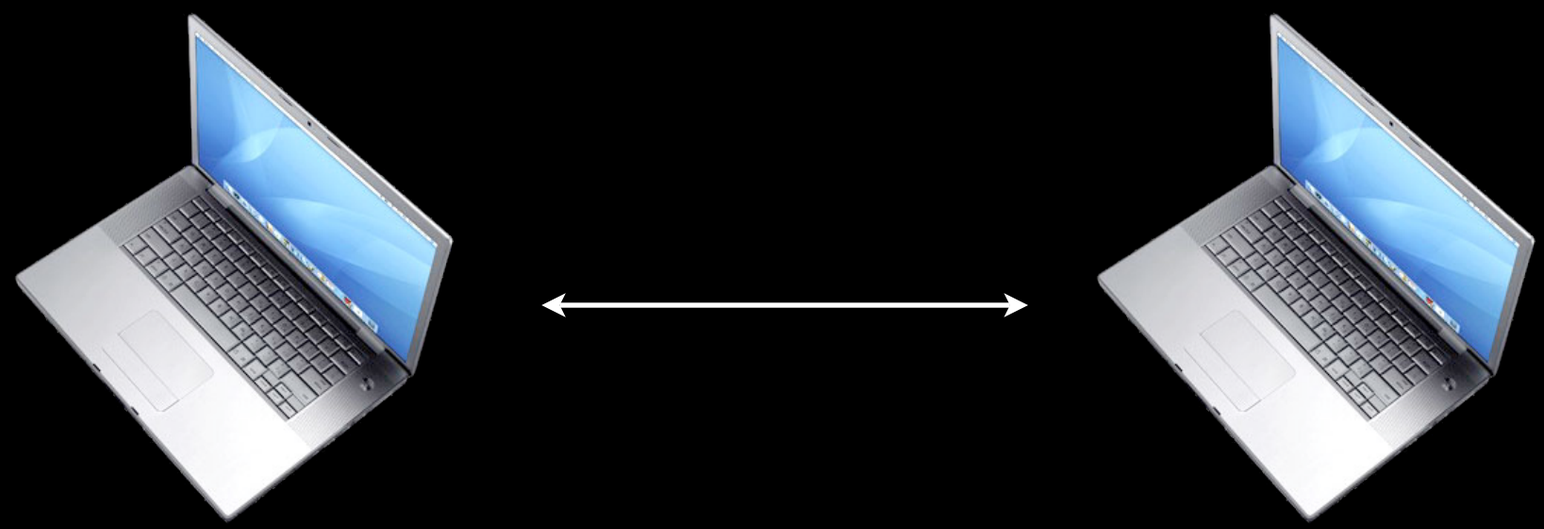
Serves over 1 Billion people worldwide

wikipedia

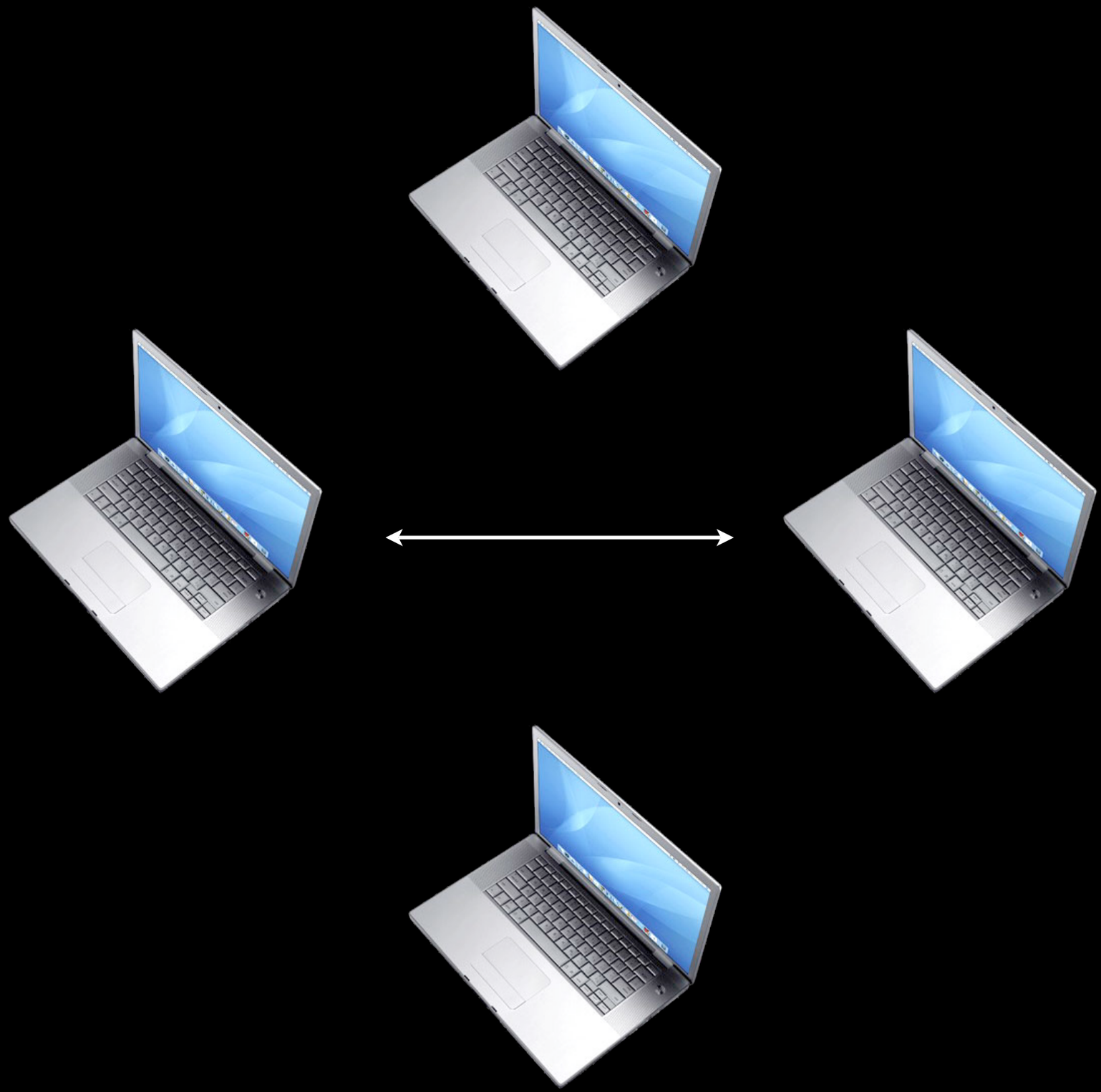
wikipedia

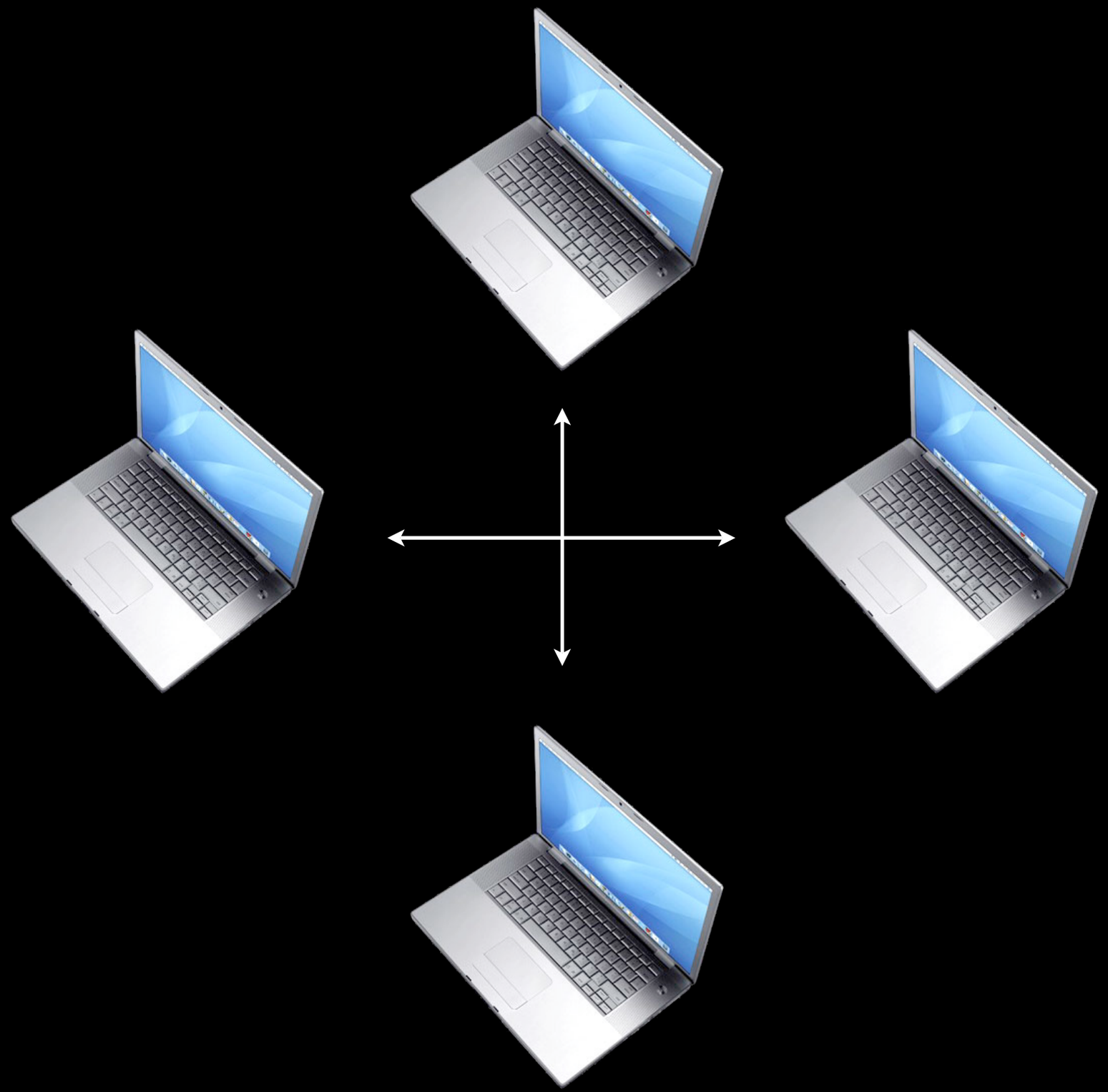


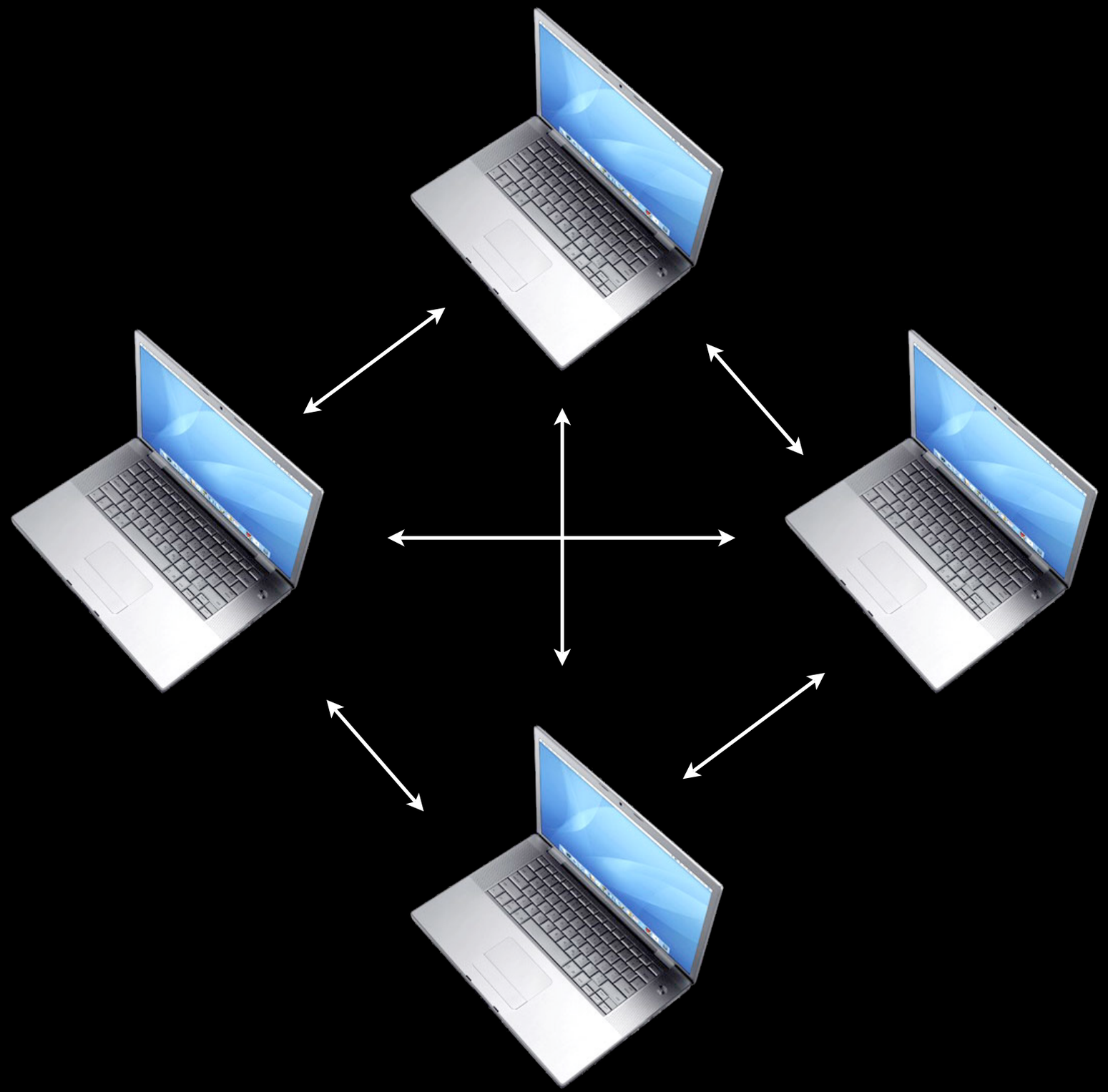
A

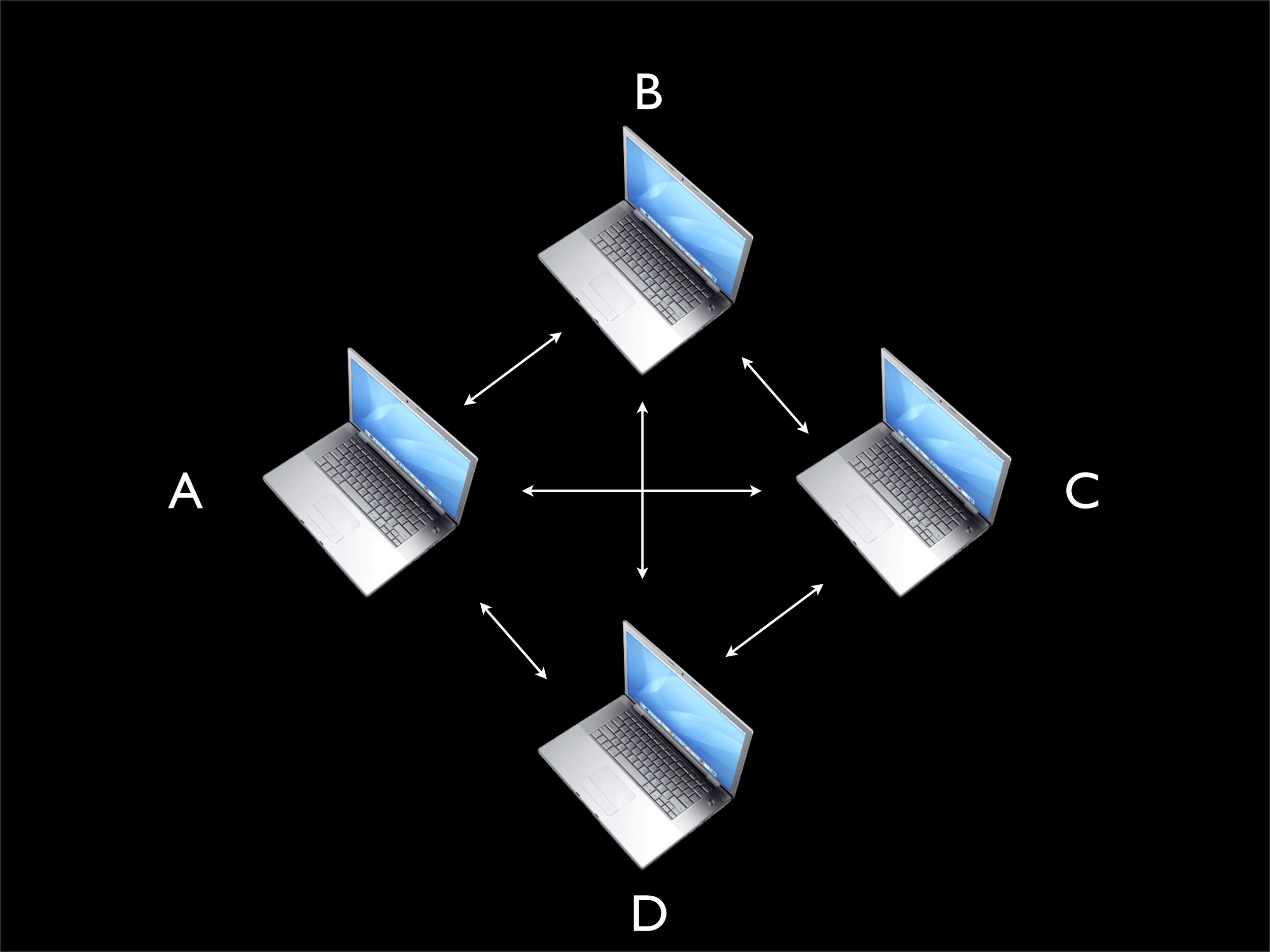


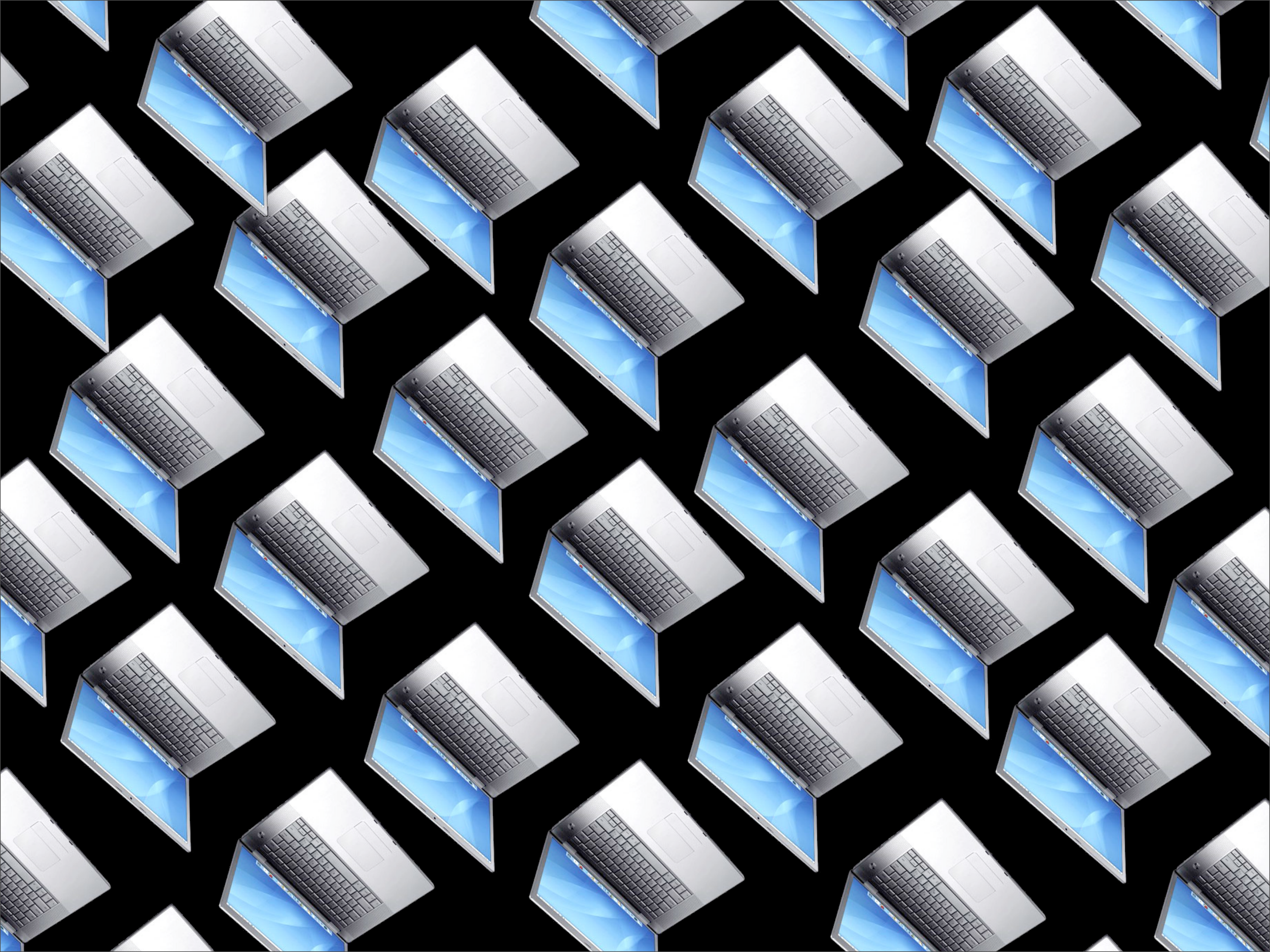
B



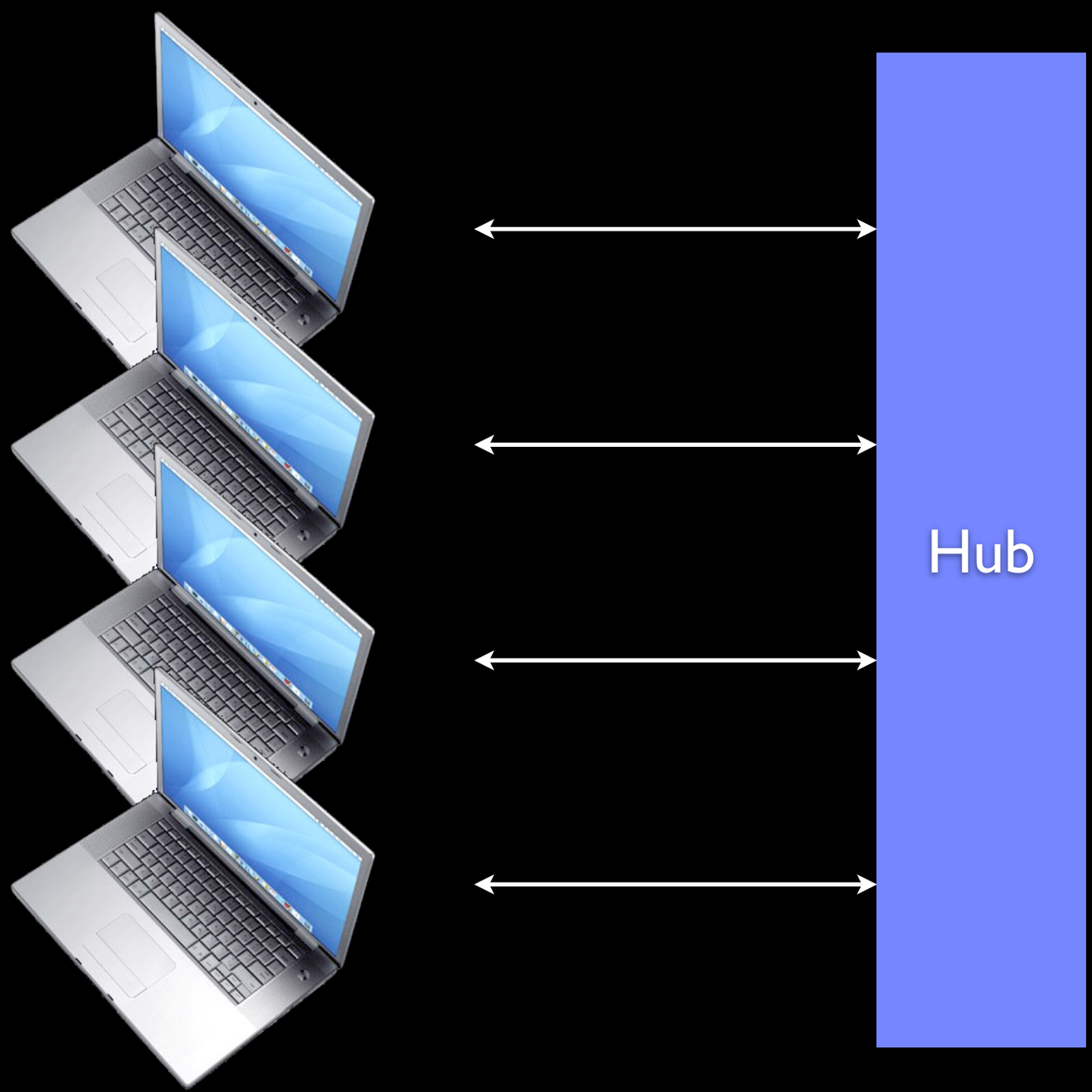





B
A
C
D



Instead of using single wires, use a “repeater”



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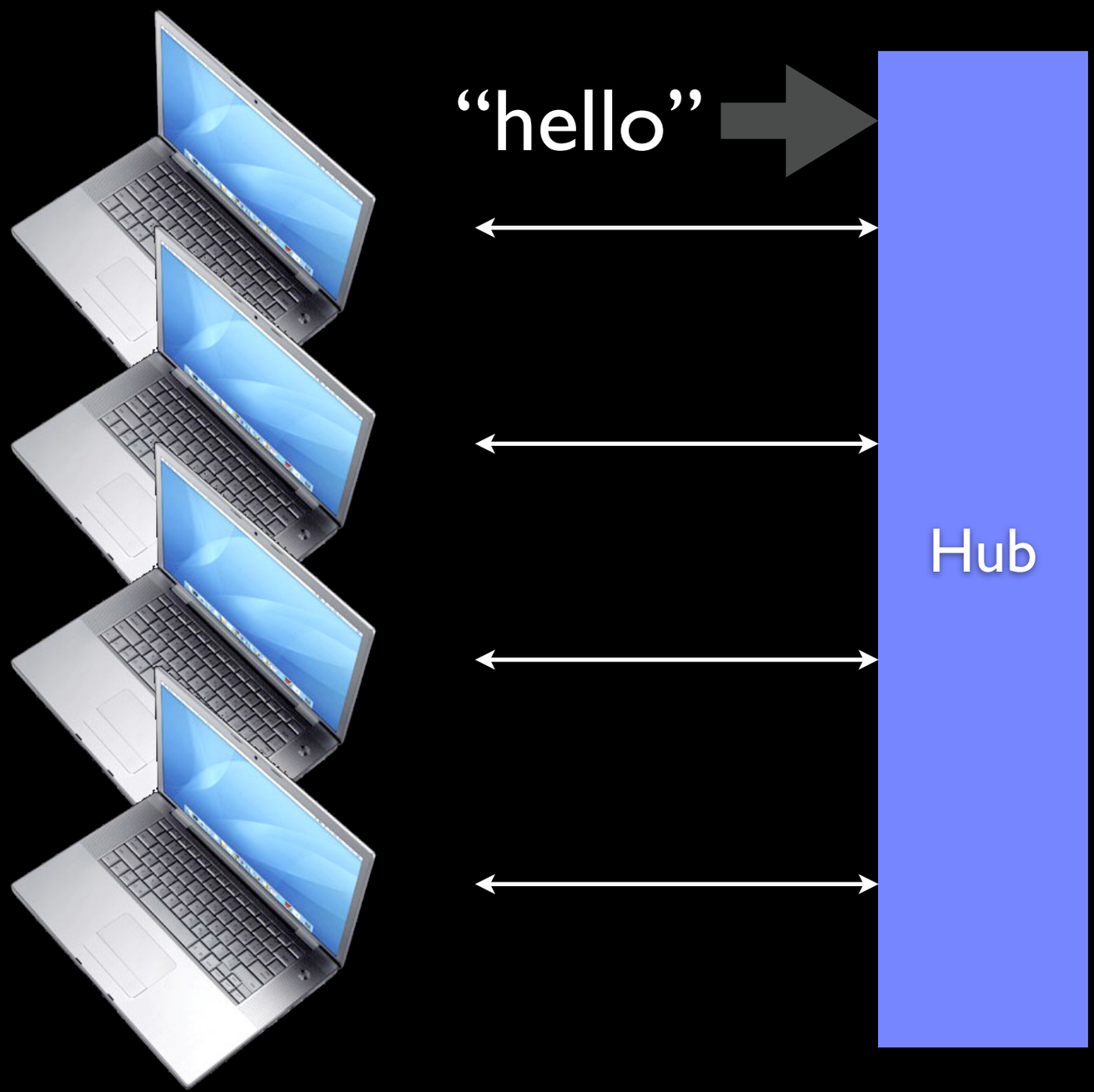
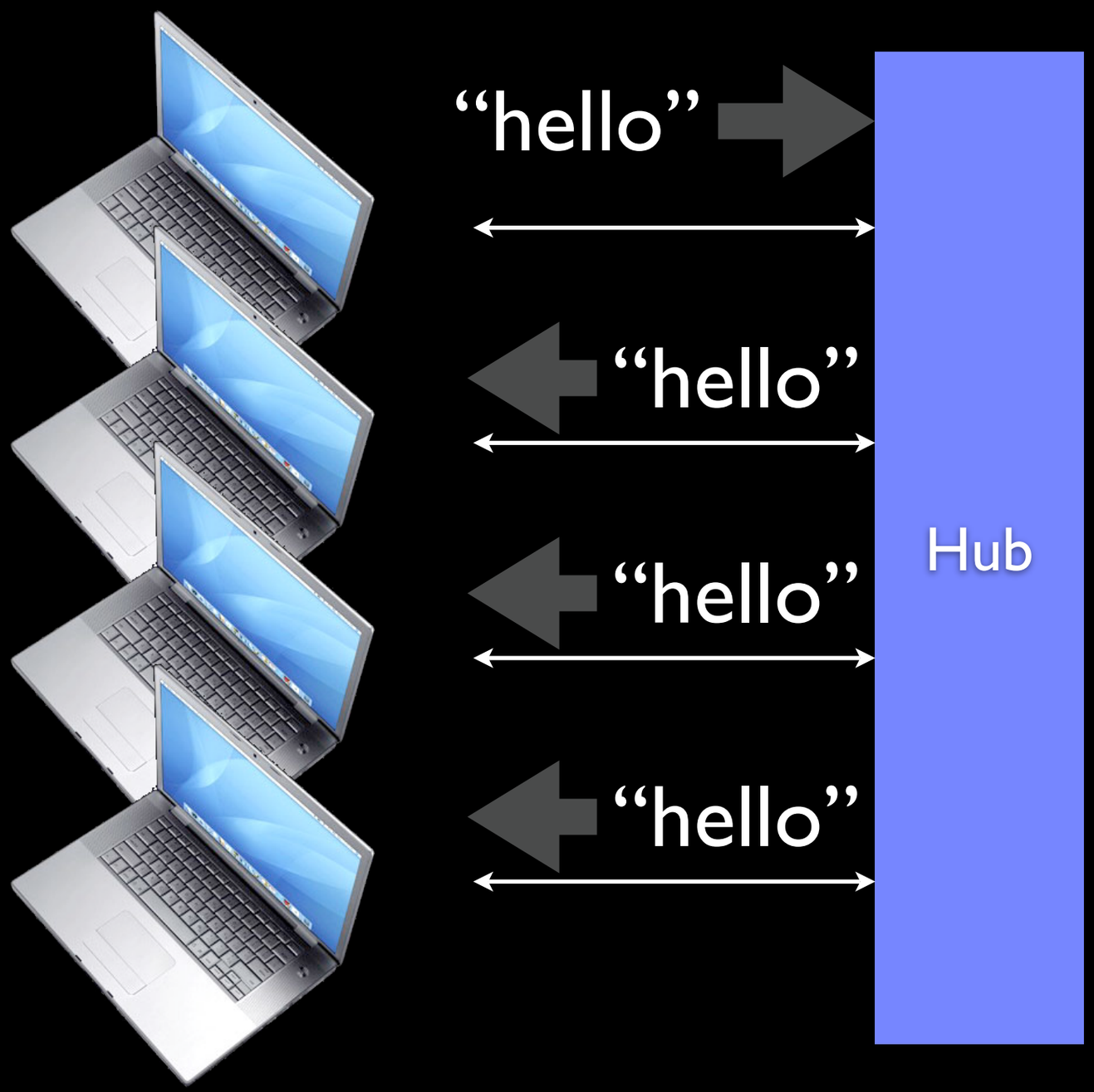
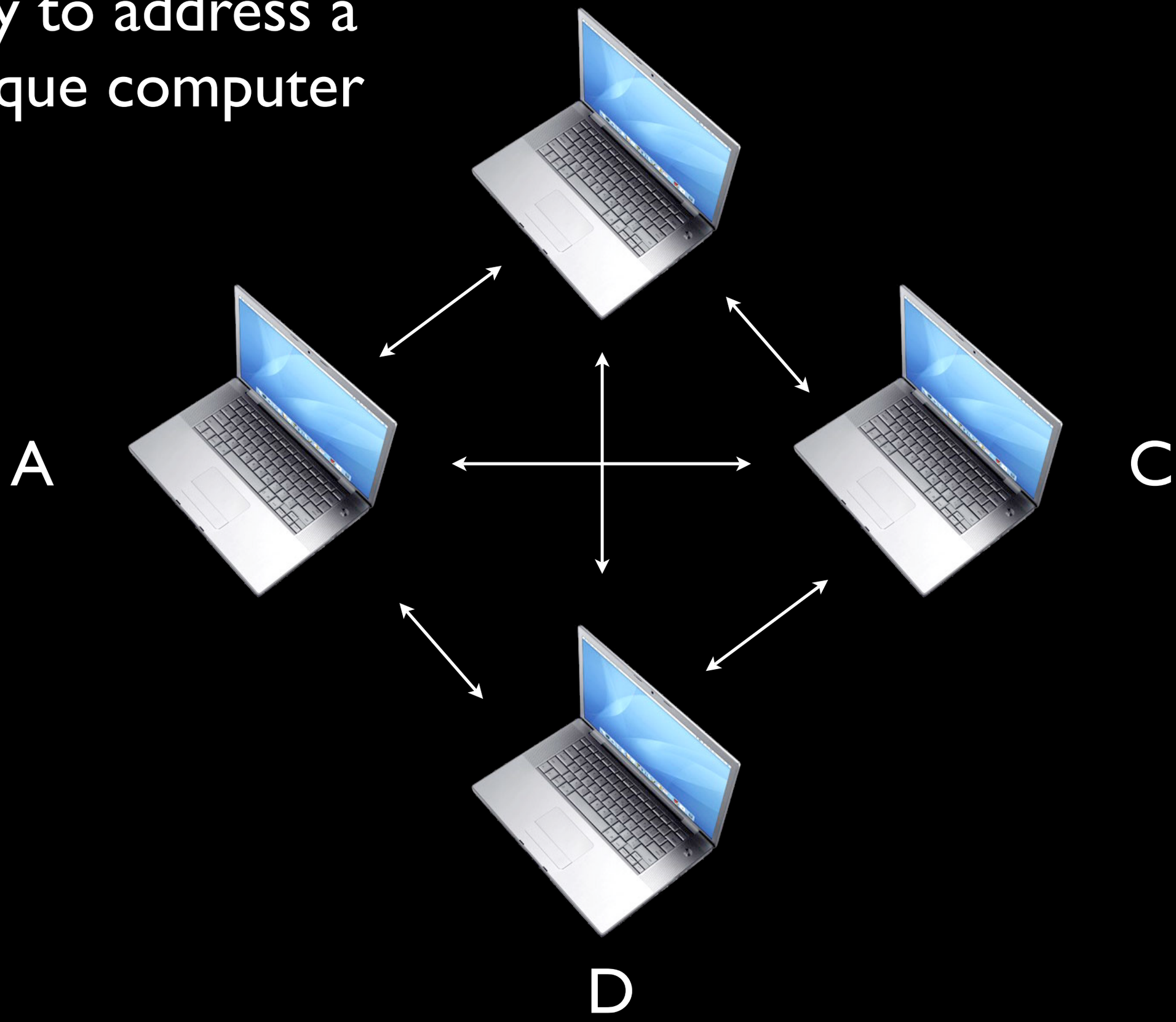


Instead of using single wires, use a “repeater”



But now, we need a way to address a unique computer



Each computer has an address

Address

1

2

3

4

Hub

Messages are encoded with destinations

Address

1

2

3

4

"hello"
to 4

Hub

Hub repeats message on every port

Address

1

2

3

4

"hello" to 4

"hello" to 4

"hello" to 4

"hello" to 4

Hub

Only the appropriate receiver "picks up"

Address

1

X 2

X 3

Y 4

"hello" to 4

"hello" to 4

"hello" to 4

"hello" to 4

Hub

But only one computer can talk at a time!

Address

1

2

3

4

"hello" to 4

"hello" to 4

"hello" to 4

"hello" to 4

Hub

Make your hub smarter

Address

1

2

3

4

"hello"
to 4

"bye"
to 3

"bye"
to 3

"hello"
to 4

Switch

This is great for small networks

Deliver a letter:
1703 Great Plain, Needham, MA 02492 USA
1710 Great Plain, Needham, MA 02492 USA

Deliver a letter:
1703 Great Plain, Needham, MA 02492 USA
1710 Great Plain, Needham, MA 02492 USA

1. Take letter across the street

Deliver a letter:
1703 Great Plain, Needham, MA 02492 USA
3400 15th Ave NE, Seattle, WA 98195 USA

Deliver a letter:
1703 Great Plain, Needham, MA 02492 USA
3400 15th Ave NE, Seattle, WA 98195 USA

1. Put letter in mailbox

Deliver a letter:
1703 Great Plain, Needham, MA 02492 USA
3400 15th Ave NE, Seattle, WA 98195 USA

1. Put letter in mailbox
2. Postal worker takes to Needham PO

Deliver a letter:
1703 Great Plain, Needham, MA 02492 USA
3400 15th Ave NE, Seattle, WA 98195 USA

1. Put letter in mailbox
2. Postal worker takes to Needham PO
3. Needham PO sends to Seattle PO

Deliver a letter:
1703 Great Plain, Needham, MA 02492 USA
3400 15th Ave NE, Seattle, WA 98195 USA

1. Put letter in mailbox
2. Postal worker takes to Needham PO
3. Needham PO sends to Seattle PO
4. Seattle PO delivers letter

1703 Great Plain, Needham, MA 02492 USA
3400 15th Ave NE, Seattle, WA 98195 USA

Addresses are great.

Increasing order of specificity (right to left):
USA > MA > Needham > Great Plain > 1703

Computers connected to the Internet also have addresses:

4.21.175.12

Increasing order of specificity (left to right):

```
4   Network owned by Level 3
21  Level 3 network leased by RCN
175 The Olin subnetwork
12  The computer (www.olin.edu)
```

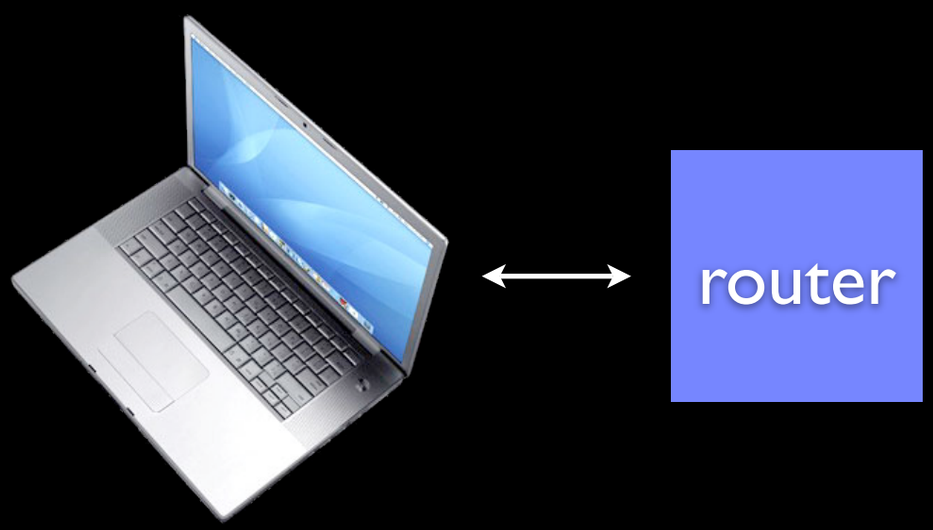
How do we get to 4.21.175.12?

How do we get to 4.21.175.12?

Your computer at home

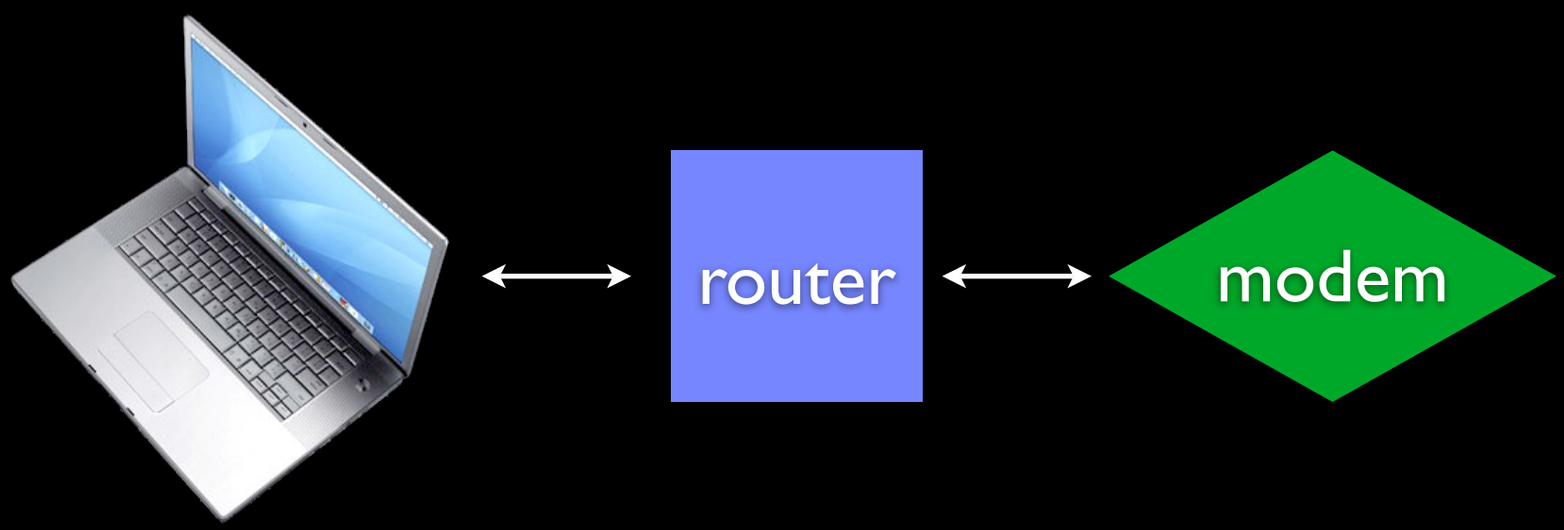
How do we get to 4.21.175.12?

A router's job is to find the best path
to get your information to its destination



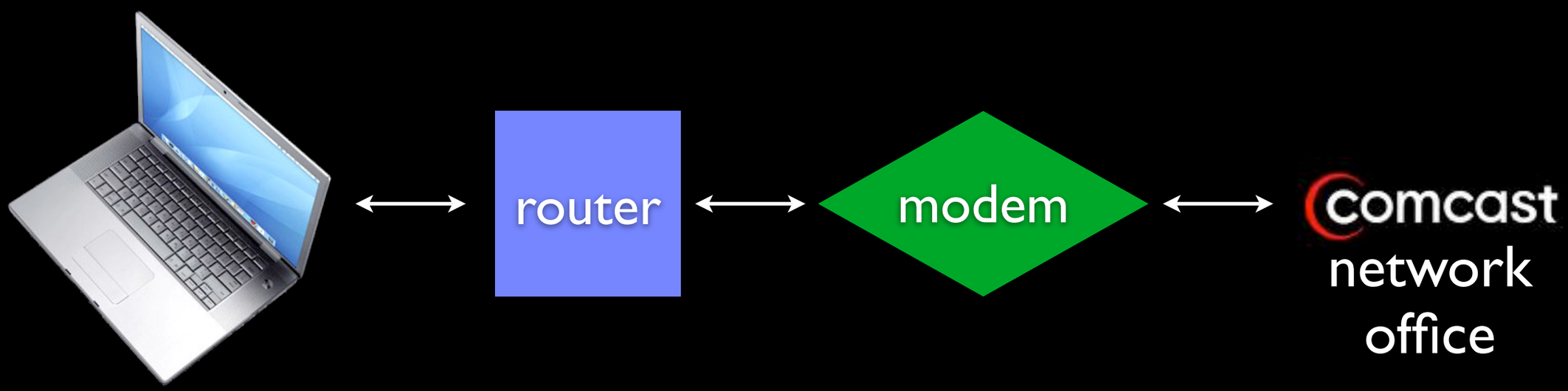
How do we get to 4.21.175.12?

Your home router knows of only a single path: through the modem



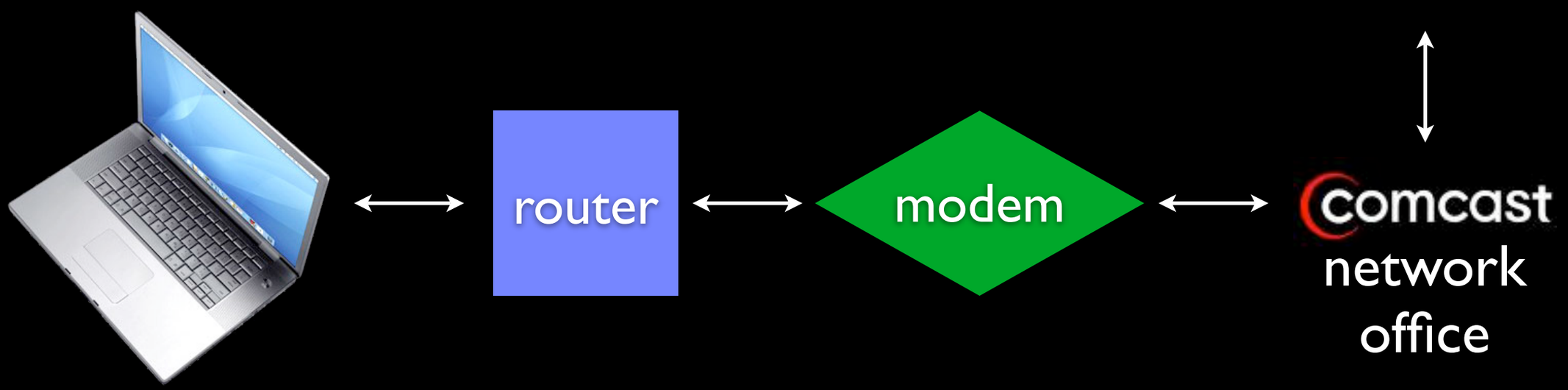
How do we get to 4.21.175.12?

... which then links your computer to your Internet provider's network



How do we get to 4.21.175.12?

... which is connected to a
large scale network backbone



How do we get to 4.21.175.12?

... that uses really big routers ...

router

modem

Level(3) COMMUNICATIONS

comcast network office

How do we get to 4.21.175.12?

... that are very tightly connected
to thousands of other links,
comprising the Internet Backbone

Level(3) COMMUNICATIONS

router

modem

comcast network office

How do we get to 4.21.175.12?

RCN ⟷ router ⟷ 

RCN ⟷ at&t

The processes goes back down the hierarchy

at&t → Level(3) COMMUNICATIONS → comcast network office → modem → router → 

But 4.21.175.12 is very hard to remember.
Humans would rather use
www.olin.edu

root

edu com net org

olin hp xe acme

www www www www

- What does this get us?
- Easy interconnection of computers globally
- Robust, distributed, adaptable network resistant to attack and failure

Unanswered

Questions?