Web Technology 2015

Lecture 2. The Internet: TCP/IP (part 1)

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Notes beforehand...

- For people who have missed lecture 1 (train problems):
    ⇒ *closely study* its contents

- proposals for Web Technology Reports:
    - received 8
    - let's discuss them after this lecture...

In the news...

Jaap Haartsen

- 1994: invented Bluetooth at Ericsson

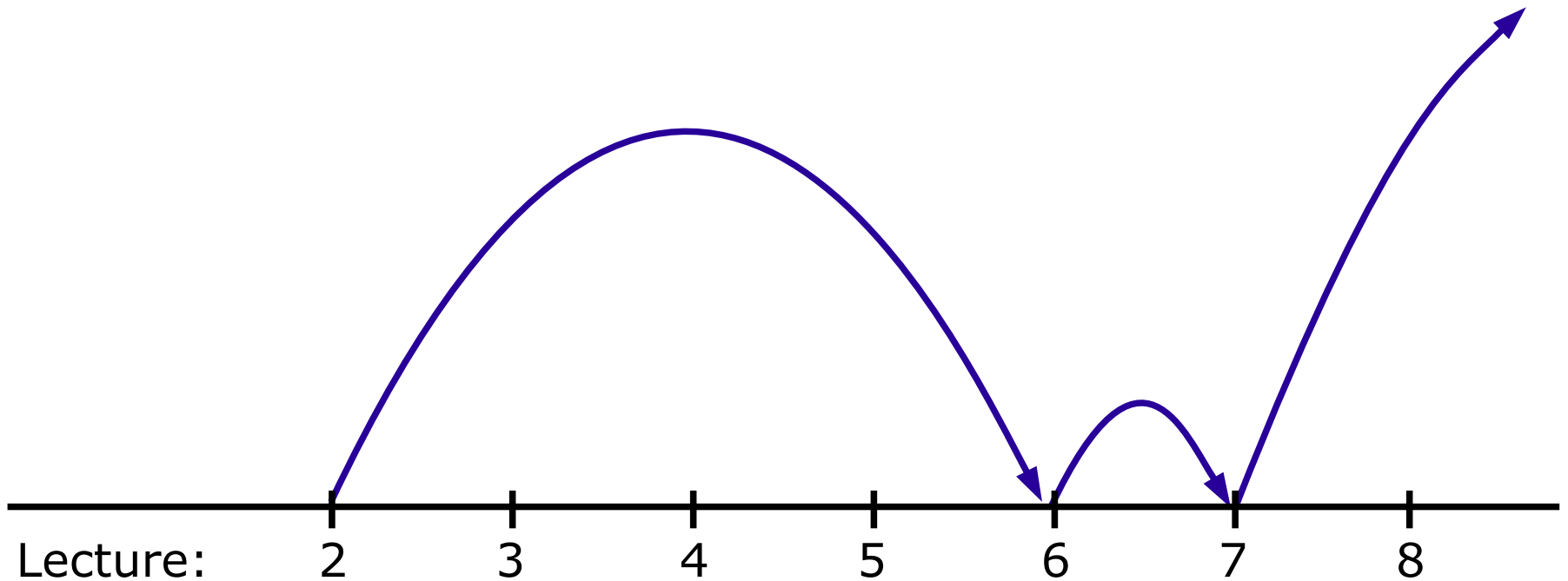- 2015: induction at the Smithsonian into the National Inventors Hall of Fame

- see e.g. http://nos.nl/artikel/2028508-nederlandse-bluetooth-uitvinder-komt-in-hall-of-fame.html
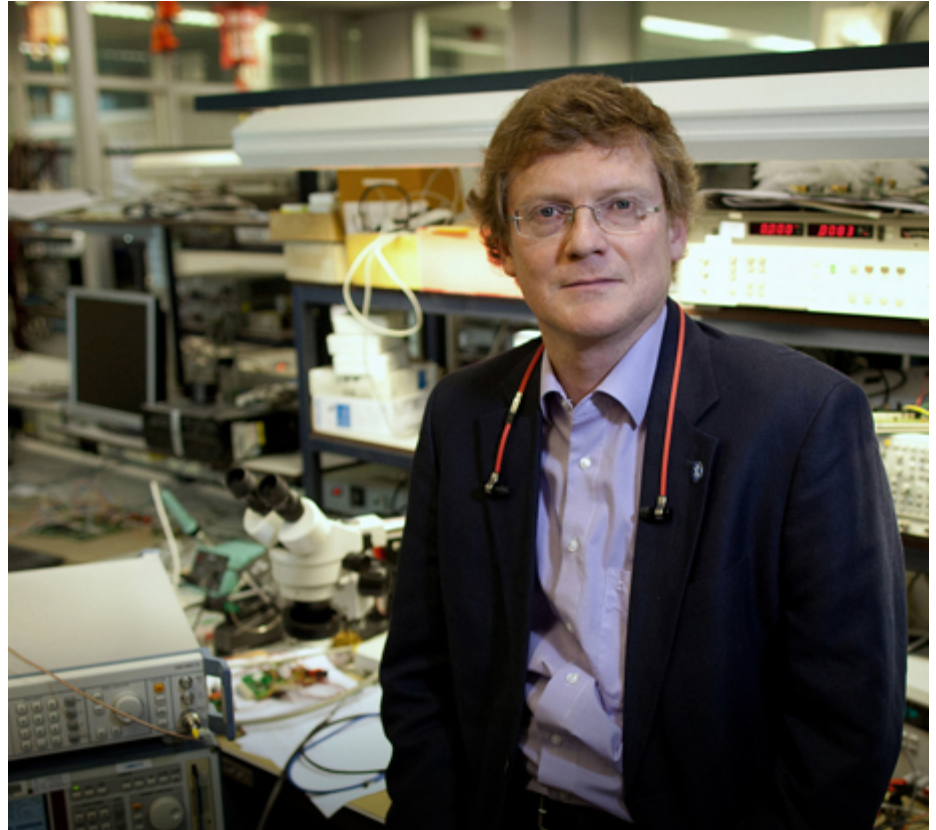
Topical overview: main arcs
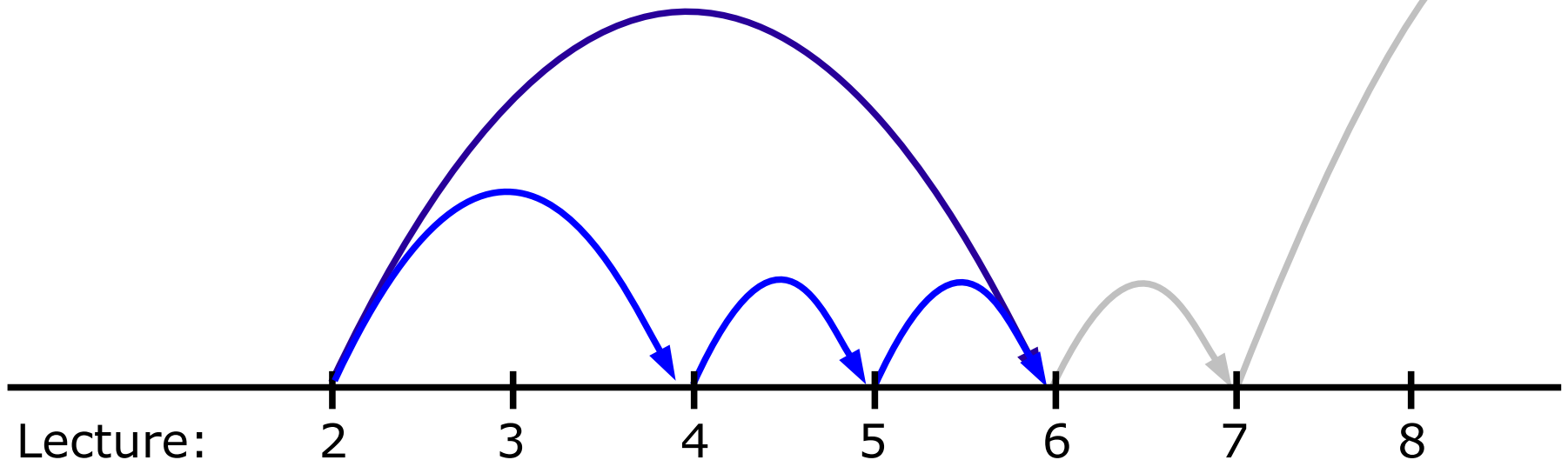
fundamental
subjects

advanced
subject

WTRs

Lecture: 2 3 4 5 6 7 8

Topical overview: zooming in

- *Next 4 sessions:* from copper wires
  to client/server programming

internetworking   WWW   client/server
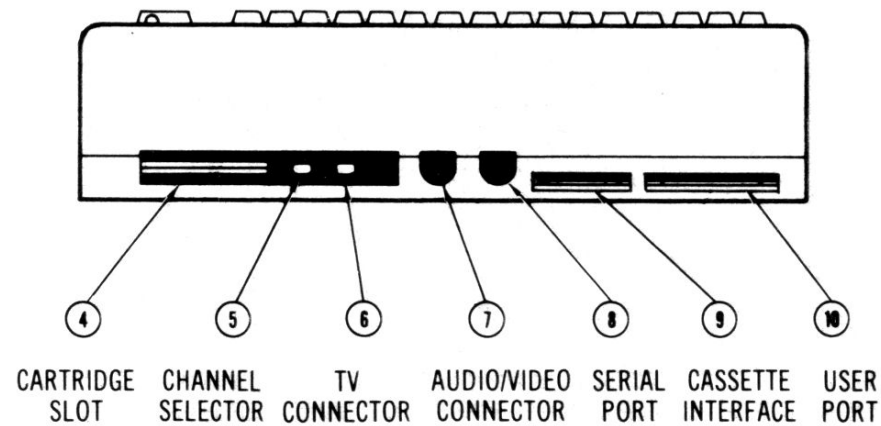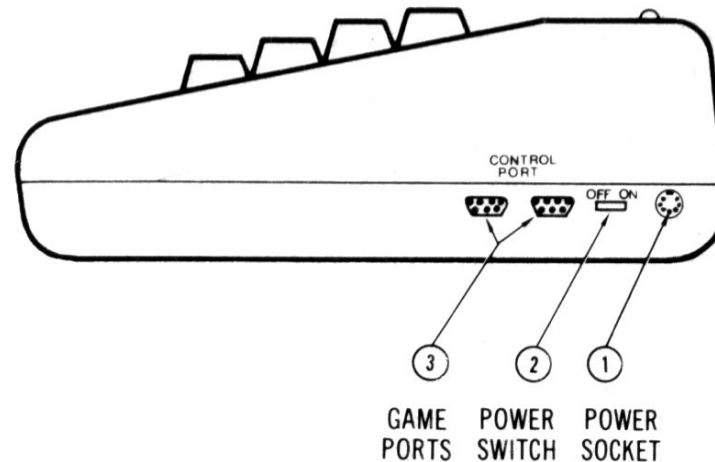   programming

Lecture: 2   3   4   5   6   7   8

Topical overview: zooming in

- Now – *internetworking* – we will discuss:

  - pairwise digital communication

  - networked digital communication

  - internetworked digital communication

- **Q:** ↑ Is there something we should discuss first ?

- **A:** Yes: *no* communication.

⇒ Necessary: *Imagine your computer is an isolated island.*

Personal anecdote 1: *magic* with symbols

Personal anecdote 1: *magic* with symbols

CONTROL PORT

OFF ON

③ GAME PORTS
② POWER SWITCH
① POWER SOCKET

④ CARTRIDGE SLOT
⑤ CHANNEL SELECTOR
⑥ TV CONNECTOR
⑦ AUDIO/VIDEO CONNECTOR
⑧ SERIAL PORT
⑨ CASSETTE INTERFACE
⑩ USER PORT

pairwise *… → networked… → internetworked* **digital communication**

In the example...

- Connecting the pair of computers enabled:

    - *communication:* via visual symbols

    - *sharing of resources:* the screen of the other computer

Personal anecdote 2: *magic* with symbols
– at greater scales

Personal anecdote 2: *magic* with symbols – at greater scales

Personal anecdote 2: *magic* with symbols
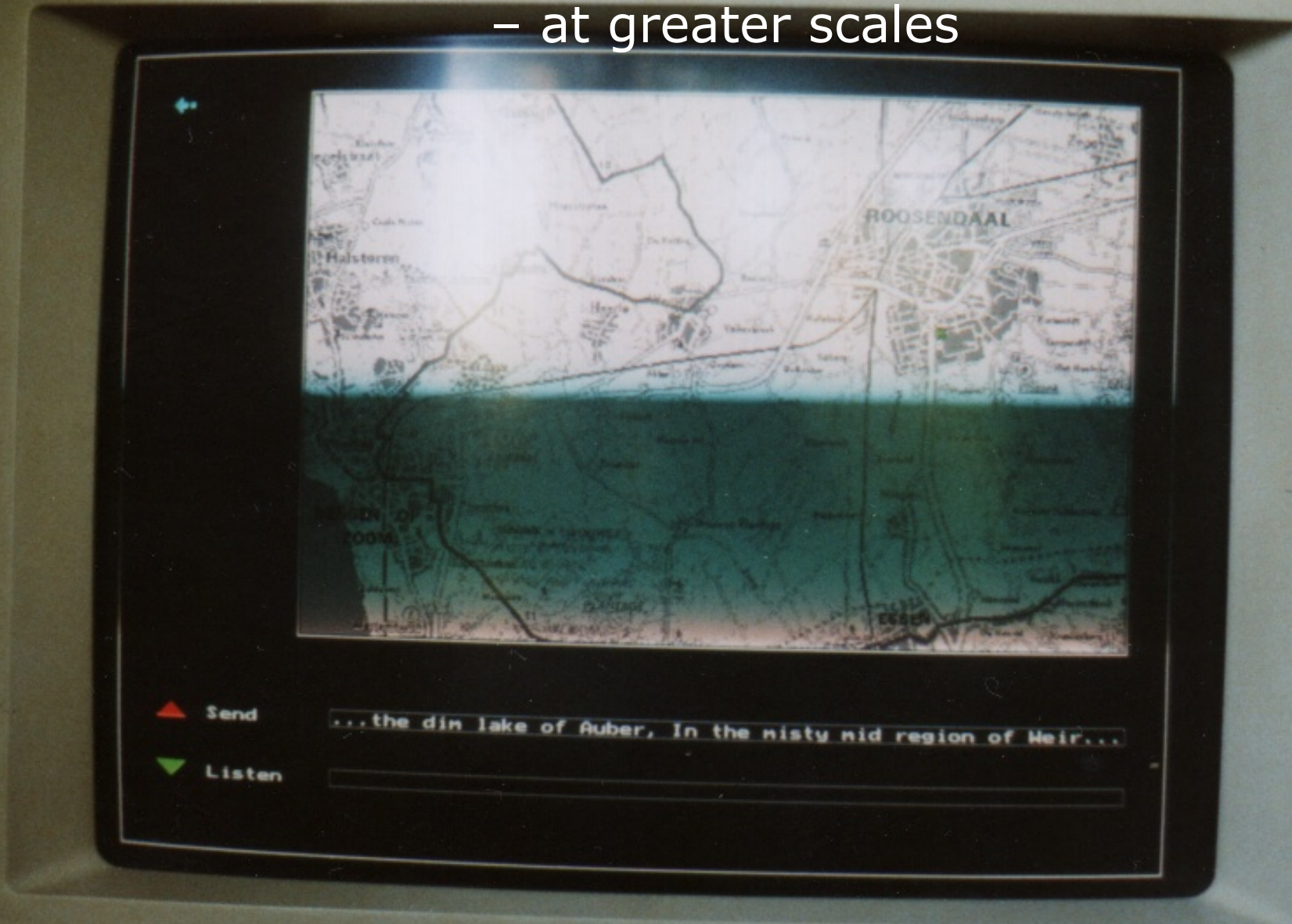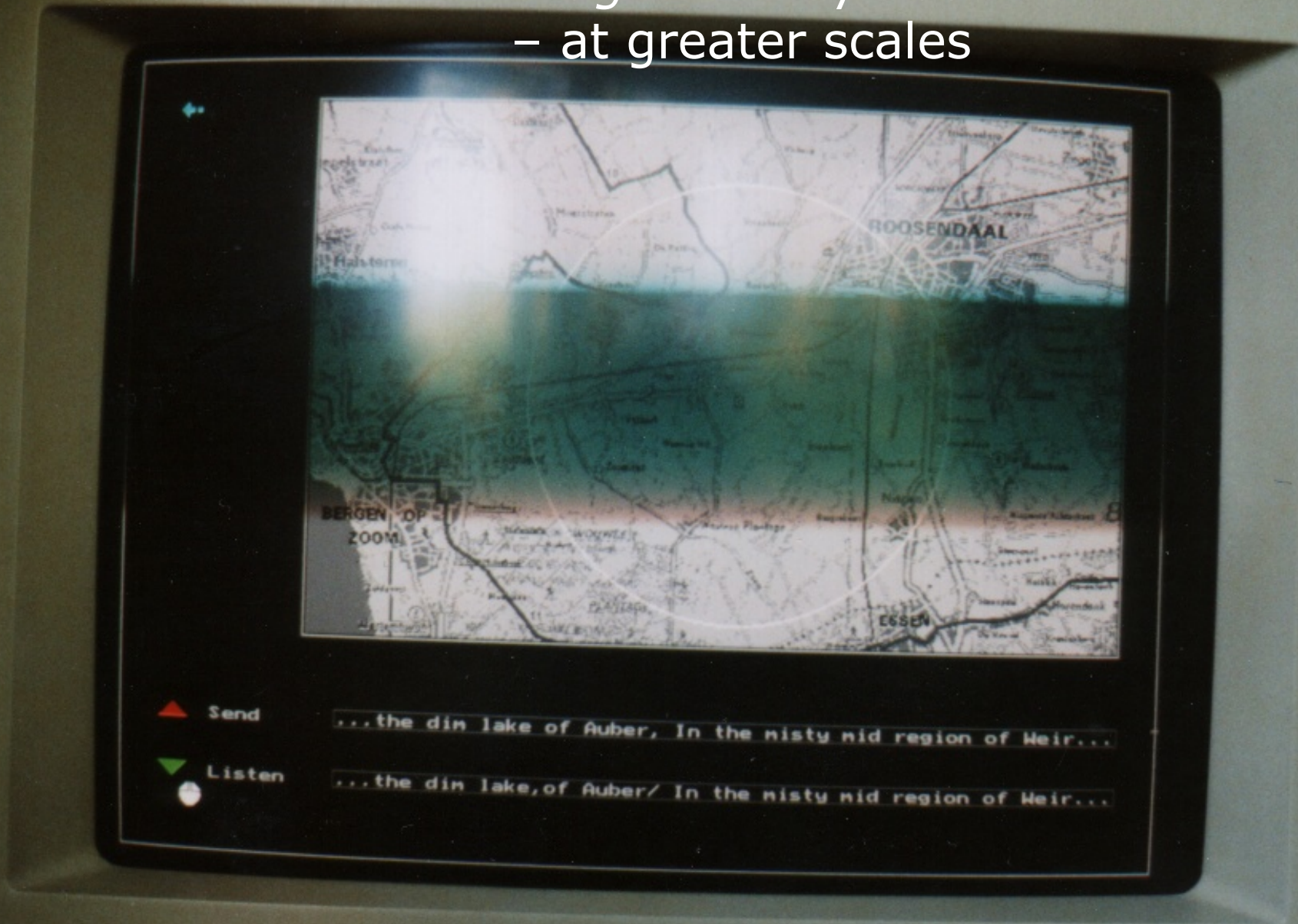– at greater scales

pairwise… → **networked**… → *internetworked* **digital communication**

Personal anecdote 2: *magic* with symbols
– at greater scales

RING PROTOTYPE
(C) 1999-2000 STAAS DE JONG

...the dim lake of Auber, In the misty mid region of Weir...

Personal anecdote 2: *magic* with symbols
## – at greater scales

Networks

- Connect multiple computers via a shared physical medium.

- Many possible physical media:
  - direct cabling (e.g. copper wires)
  - telephone line
  - wireless connection (radio)
  - ...

 ⇒ The computers can now cause changes to eachother's state.

- This enables communication and sharing of resources
  - (e.g. messaging, mail, data storage, printing devices, games, videoconferencing, ...).
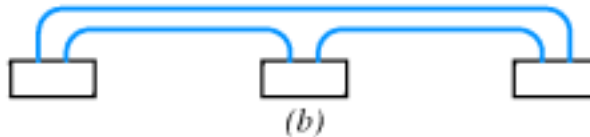
Networks: the problem of scalability

- Use of pairwise dedicated physical communication channels
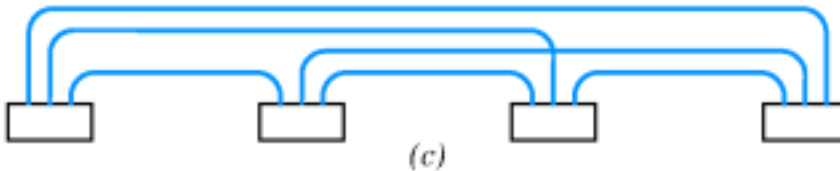 - only works well for a small number of machines
  - i.e., does not *scale:*

n = 2

(a)

n = 3

(b)

n = 4

(c)
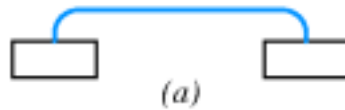
↑ Think of what happens over n the number of machines;
                    and over increasing geographical distance.

A solution: Packet switching

- Most networks use *packet switching:*
  - Data is split up and sent in discrete chunks (packets).
  - Each packet is individually routed to its destination.
  - Multiple data streams can be sent simultaneously by interleaving packet streams.
    - ↑ ⇒ scalability!

- Not all packets will necessarily
  - follow the same route
  - arrive after similar periods.

- *Analogy:* small postal cars
  - racing down shared highways
  - each carrying one box (packet) with data
    - possibly a small chunk of a larger data transfer.

LAN: Local Area Network

- Classical example.

- Covers a small local area, like a home, office, or group of buildings. →

- E.g. using *Ethernet*, but there are also other (W)LAN technologies, such as Token ring, *Wi-Fi*.

- So that they can send eachother messages, the computers on a LAN each have an identifying *hardware address*.
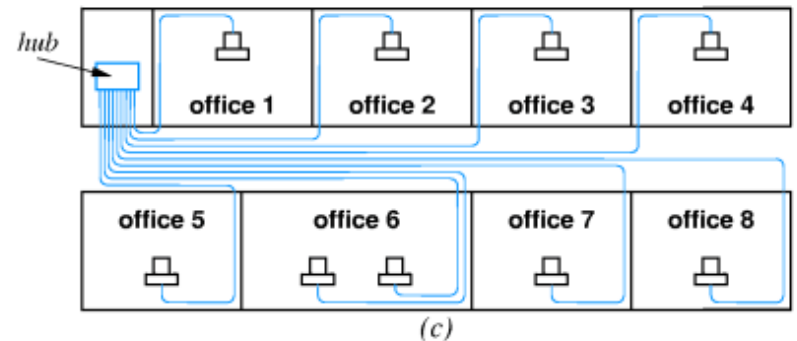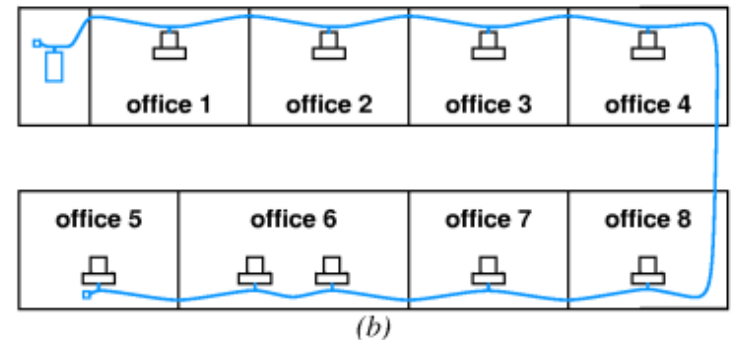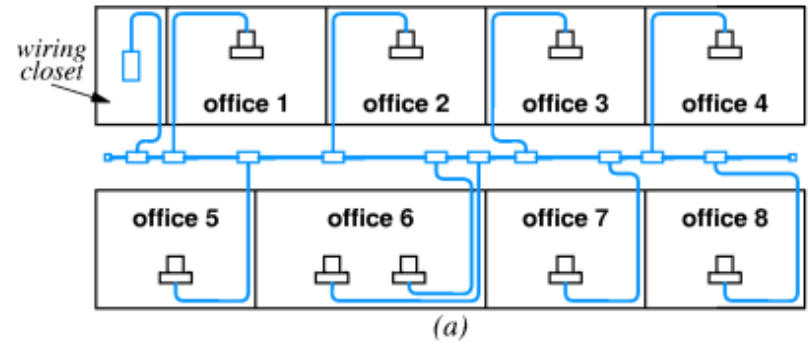
Connecting *networks*

- *Motivation:*
  communication & resource sharing is extended even further
  by connecting different networks!

- *However, different network technologies are incompatible:*
  different physical media;
  different addressing schemes;
  different packet sizes;
  different internal data formats;
  etc.

- *One approach:* ad hoc solutions, connecting different pairs.

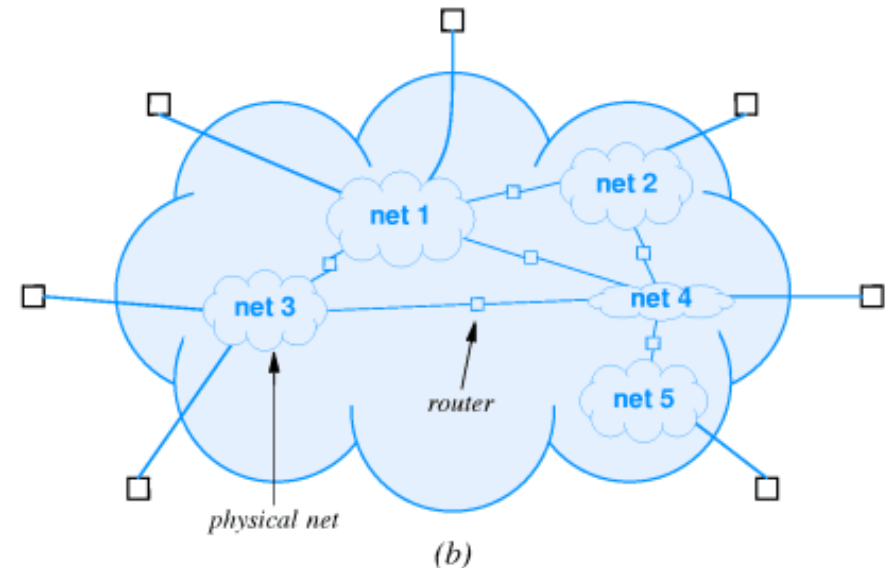⇒ *Better solution:* build a *virtual* network on top of *physical* ones.

↑ An *internetwork*.

Internetworks

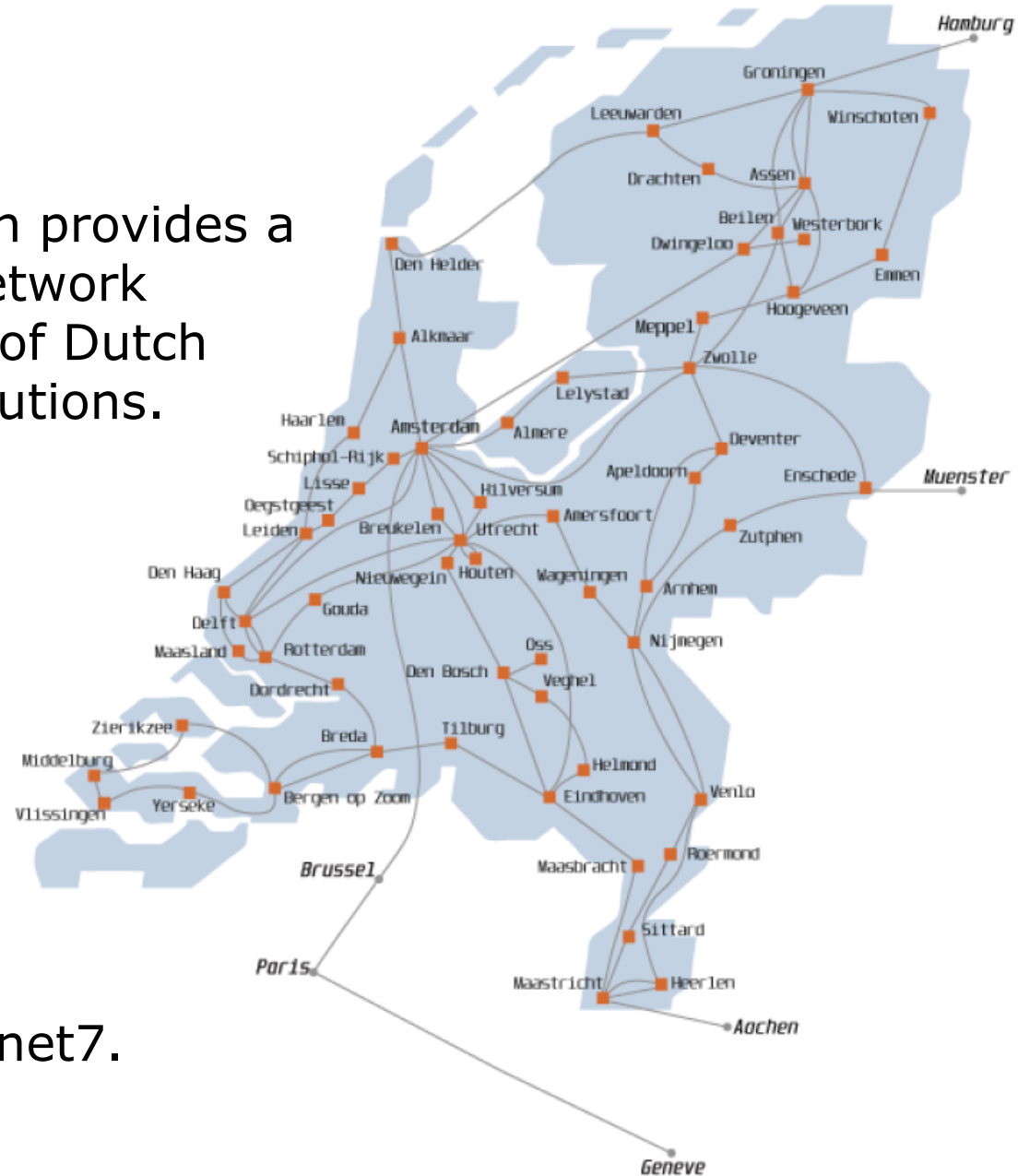Result in

(a) the appearance of a single network...
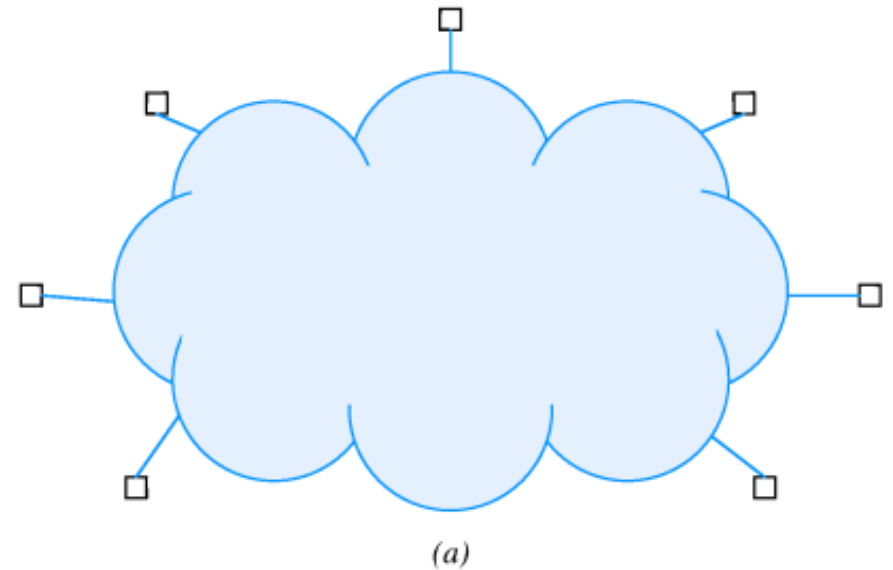
(b) ...despite the underlying structure.

(a)

net 2

net 1

net 3

net 4

router

net 5

physical net

(b)

An example internetwork: SURFnet7

- The SURFnet organization provides a very high quality internetwork between local networks of Dutch higher educational institutions.


- *Latest incarnation:* SURFnet7.

The Internet

- The world's largest public internetwork.

- 'Computers' can be…

  - smartphones, tablets, laptops, desktop PCs, dedicated servers, mainframes, microwave ovens, soda machines, …

  - running Linux, Windows, Mac OS X, Unix, etc…

  - connected by Wi-Fi, Ethernet, Token Ring, FDDI, ADSL, ATM, Frame Relay, etc…
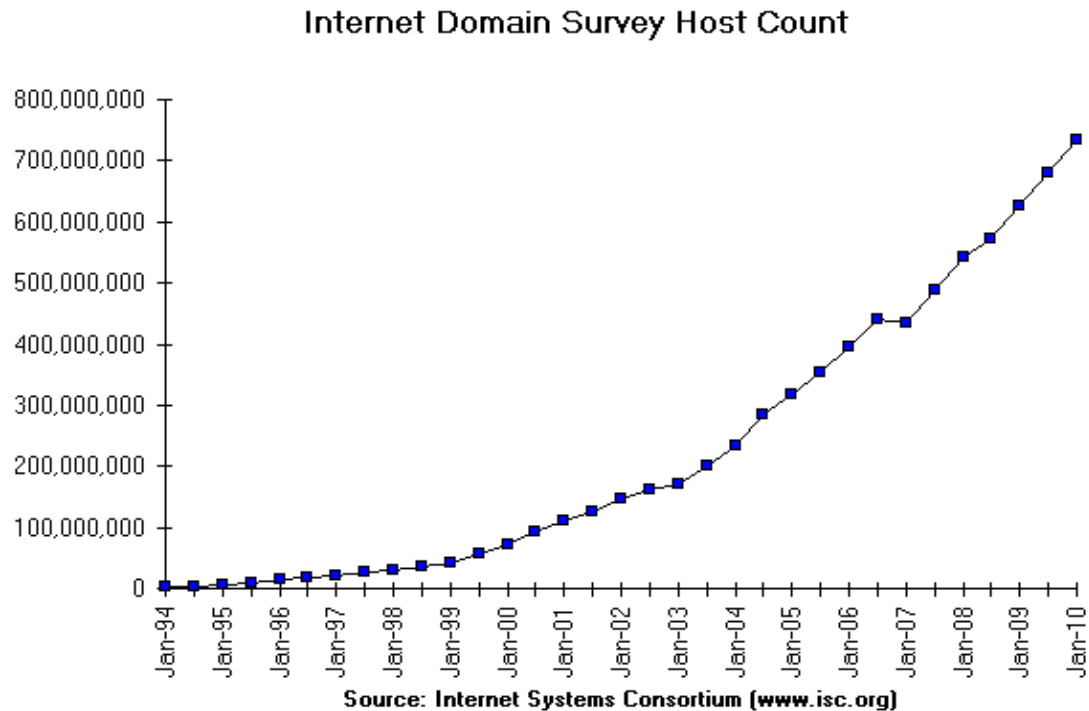
The Internet

- Started as a research project connecting 4 computers.

- Has shown *exponential growth*;
  see the Internet Domain Survey at www.isc.org/ds/ .

Internet Domain Survey Host Count

Source: Internet Software Consortium (www.isc.org)
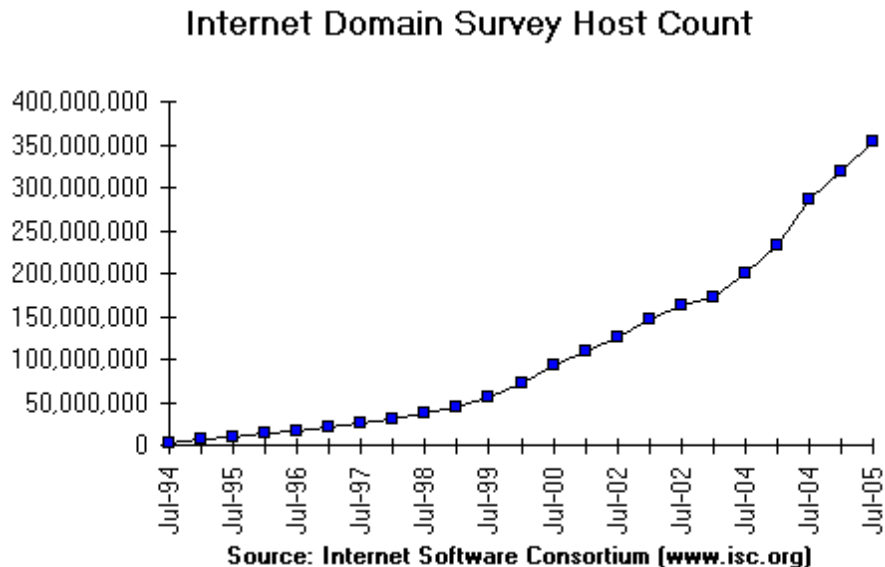
- **Q:** What do you suppose happened post-2005?

The Internet

Internet Domain Survey Host Count

Source: Internet Systems Consortium (www.isc.org)
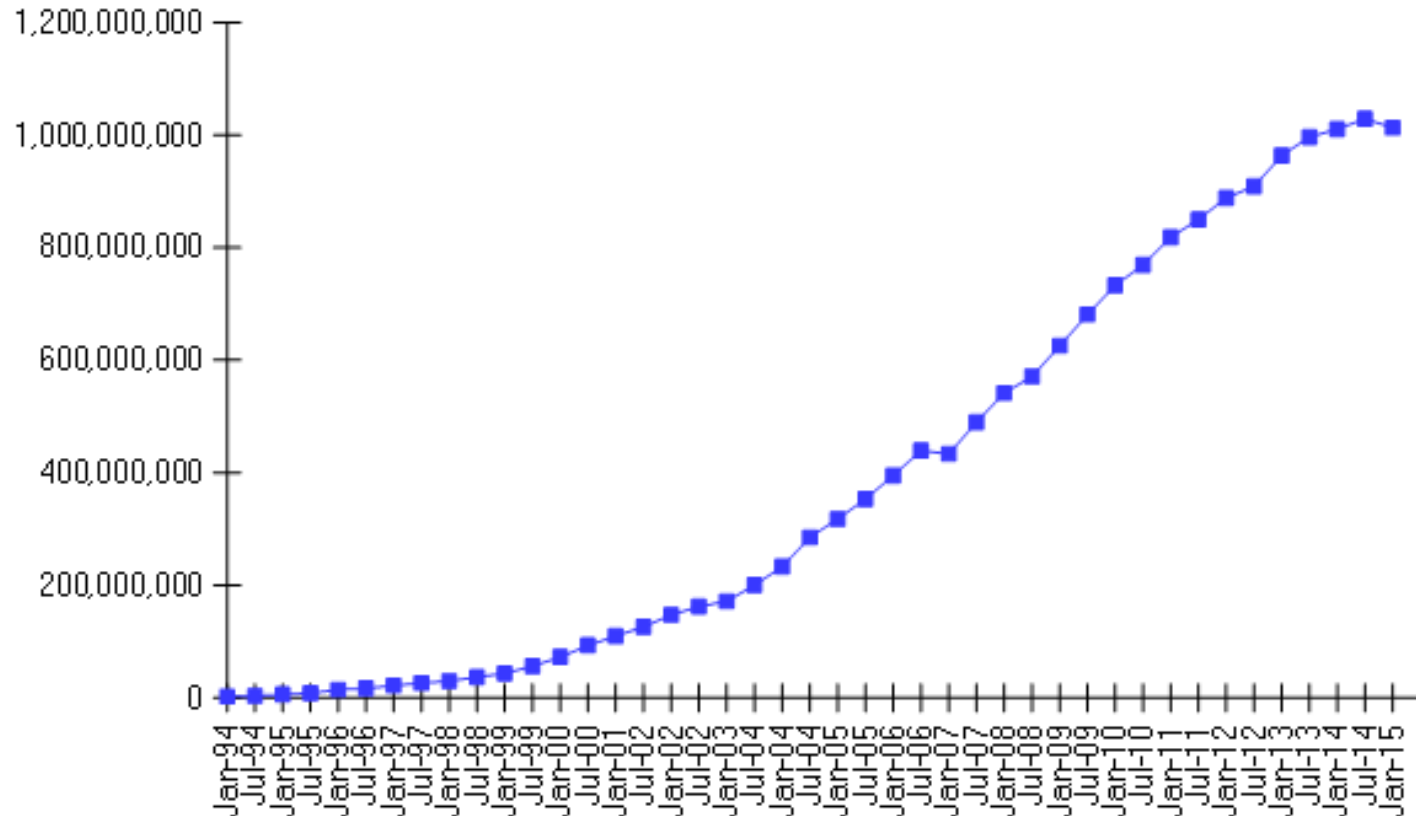
- **Q:** What do you suppose happened post-2010?
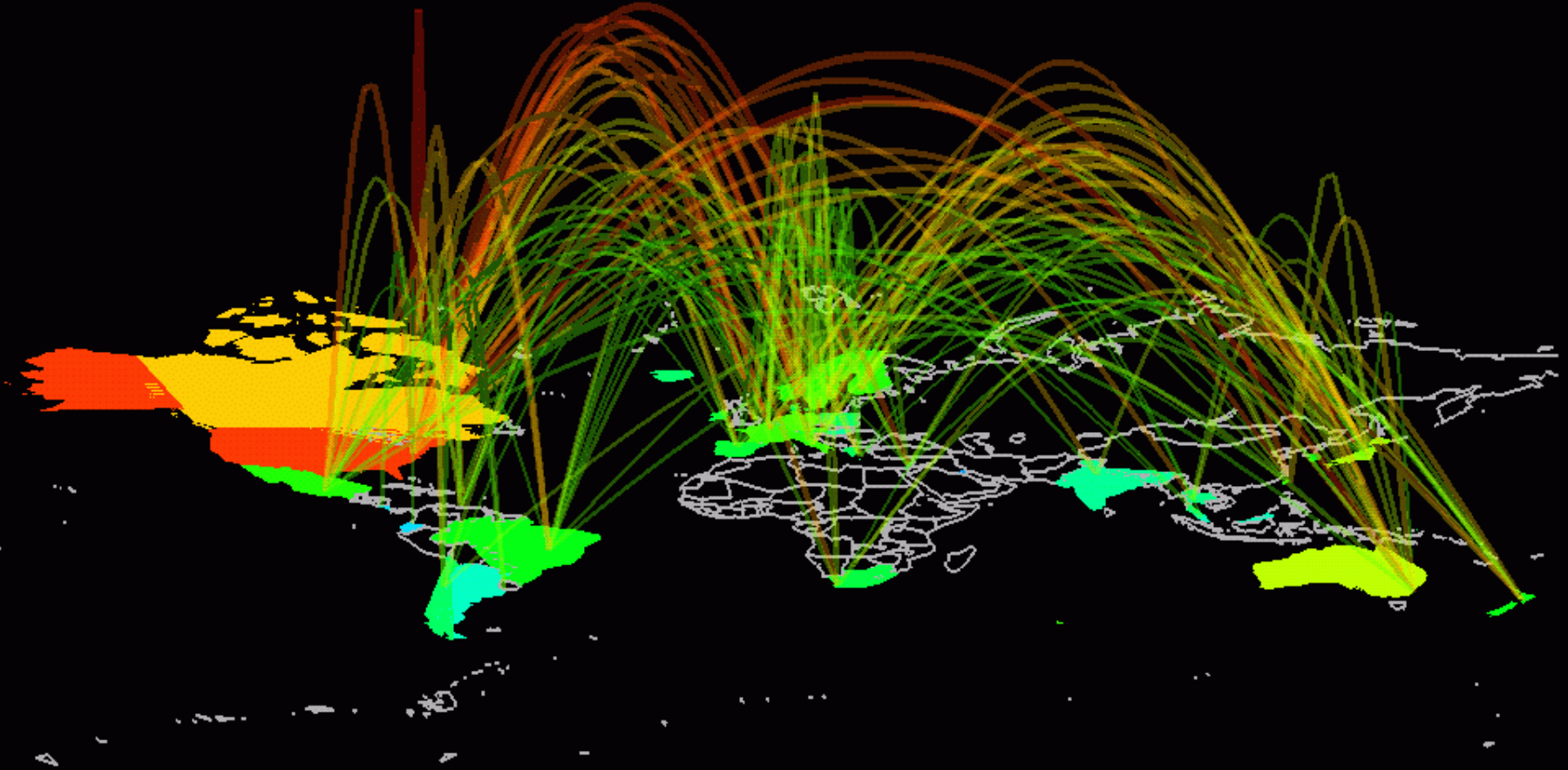
The Internet

Internet Domain Survey Host Count

Source: Internet Systems Consortium (www.isc.org)

... ⇒ Takeaway: (1) there was an exponential growth phase
(2) notice the scales on the vertical axis.

Next: how to make an Internet

↑ Image: late 1990s Internet traffic flow visualization, by Stephen Eick.

But first...

BREAK