Networks

History

- Email and discussion groups are immediately popular

Networks

History

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- 1973 Internet reaches London

Networks

History

- Email and discussion groups are immediately popular
- 1973 Internet reaches London
- 1974 TCP/IP replaces NCP

Networks

History

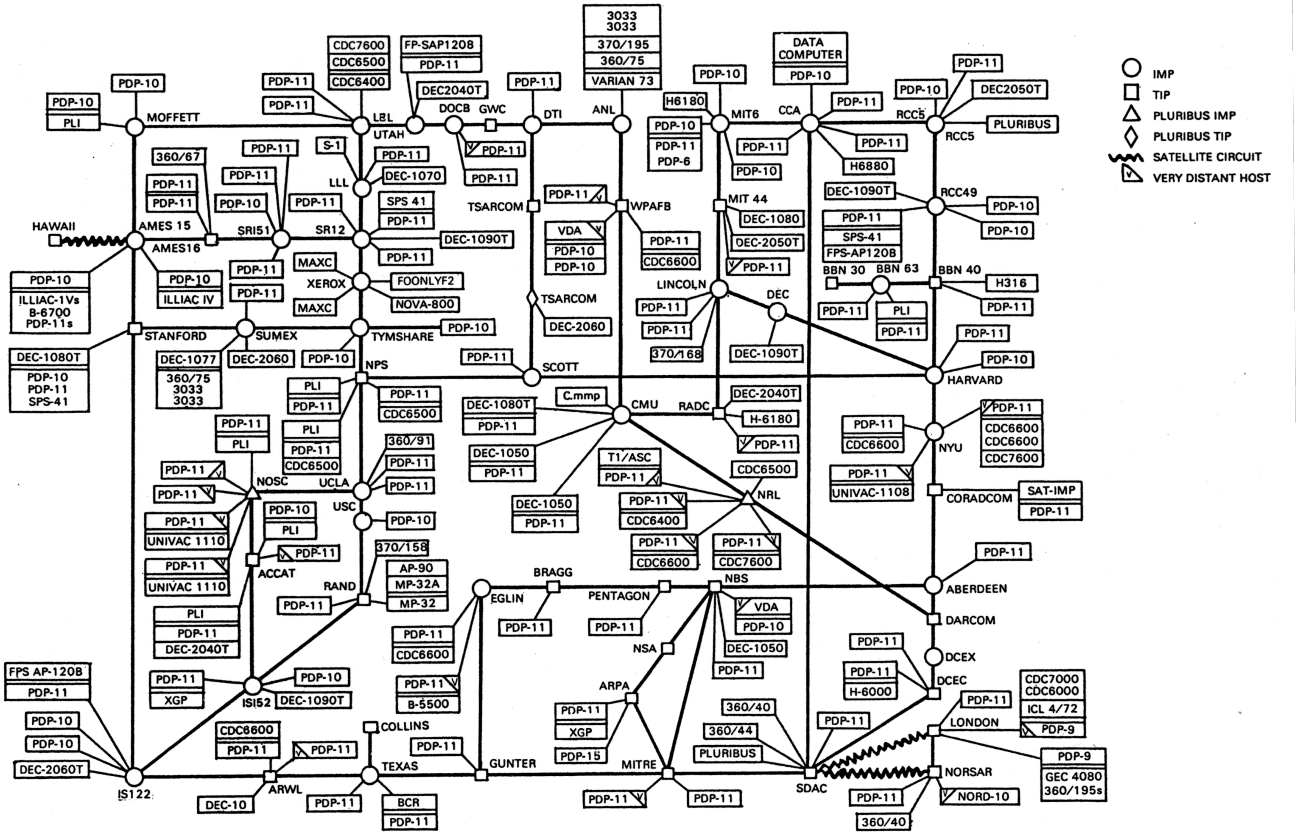

FIGURE 7.1: ARPANET LOGICAL MAP, JUNE 1979

Arpanet in 1979, from “Computer Networks, Fundamentals, Practice”; Bacon, Stokes, Bacon, 1984

Networks

History

- 1980s 1000s of machines on the Internet

Networks

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Networks

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- 1992 1,000,000 hosts
- Gopher
- Tim Berners-Lee invents the Web

Networks

History

- The Internet starts to enter the home

Networks

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- Microsoft gives up on its own network and falls into line

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- Broadband to the home
- Large commerce over the Internet

Networks

History

- Mobile revolution

Networks

History

- Mobile revolution
- “Social” media

Networks

History

- Mobile revolution
- “Social” media
- Internet of Things (IoT); blockchain; etc.

Networks

History

- Mobile revolution
- “Social” media
- Internet of Things (IoT); blockchain; etc.
- . . . what next?

Networks

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Networks

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Networks

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Networks

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- how to chunk the data into packets?
- how are route(s) the packets use to get to their destination found?
- how do we reconstruct the original data as packets might be arriving in any order?

And higher level decisions like how we shall choose and build these multiple routes; what hardware to use, and so on

Networks

A packet doesn’t know how to get to its destination

Networks

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The question now becomes: how do the routers know what to do? More on this later

Networks

Protocols

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Networks

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Networks

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But you must have standards in the software too, as becomes clear when you try to use a Web page authoring tool that doesn't produce standard HTML

Thus we must have standards for the protocols

Networks

Protocols

This is somewhat akin to people agreeing all to use English (for example) to communicate

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A pair of random people meeting can talk if they both know English

Networks

Protocols

This is somewhat akin to people agreeing all to use English (for example) to communicate

A pair of random people meeting can talk if they both know English

If not, the chances are that they share their native languages are quite small

Networks

Protocols

The Internet has a collection of specifications called *Request for Comments*, or *RFCs*

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> *Be as close to the RFC as possible in what you do yourself, but be as liberal as possible regarding what you accept from others*

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Continuing Exercise When a topic is covered in lectures, read the relevant RFCs

Networks

Protocols

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- Internet Engineering Steering Group (IESG); executive sub-committee of IETF that has final say over RFCs

Networks

Protocols

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- Internet Research Steering Group (IRSG); sub-committee of IRTF that manages the research groups
- Internet Corporation for Assigned Names and Numbers (ICANN); nonprofit internationally-organised organisation to oversee (sets policy) for global resources such as names and numbers or other identifiers
- Internet Assigned Numbers Authority (IANA); an affiliate body to ICANN that actually manages the domain names, IP addresses and other things, currently run by a company named “Public Technical Identifiers”

Networks

Protocols

IANA delegates management of various things to *Regional Internet Registries* (RIRs), e.g., domain names and addresses

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Protocols

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Current RIRs:

- African Network Information Centre (AfriNIC); Africa
- American Registry for Internet Numbers (ARIN); North America and Antarctica
- Asia-Pacific Network Information Centre (APNIC); Asia, Australia, New Zealand
- Latin America and Caribbean Network Information Centre (LACNIC); South America
- Réseaux IP Européns Network Coordination Centre (RIPE); Europe, Russia, the Middle East, and Central Asia

Networks

Protocols

These are geographical, not political, regions

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The RIRs further delegate things like management of domain names to commercial companies

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Protocols

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Exercise Trace the movement of money up this hierarchy

Networks

Protocols

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- IEEE Institute for Electric and Electronic Engineers; hardware like Ethernet and Wi-Fi

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- IEC International Electrotechnical Commission; e.g., Digital Living Network Alliance (DLNA)
- ITU-T Telecommunication Standardization Sector of the ITU (International Telecommunication Union); e.g., DSL standards
- lots more national and international institutions, such as the British Standards Institution (BSI)

Networks

Protocols

There is quite a lot of overlap in what these institutions cover

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For example, the JPEG standard, from the Joint Photographic Experts Group, is the same as ISO standard 10918-6:2013 and ITU-T T.872

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Exercise Investigate these standards bodies

Networks

History

Anyway, we need a common “language” (the protocols) for a network

Networks

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For the Internet, this common language is called the *Transmission Control Protocol/Internet Protocol* (TCP/IP)

Networks

History

Anyway, we need a common “language” (the protocols) for a network

For the Internet, this common language is called the *Transmission Control Protocol/Internet Protocol* (TCP/IP)

This name is more historical than accurate, but to see what it means we need to think of *layers*

Networks

Layering Models

What do we need to make two computers communicate?

Networks

Layering Models

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We need to connect them, so there must be some kind of physical (electrical, optical, radio or other) thing between them

Networks

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Networks

Layering Models

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And they must agree on how to represent data as bits: recall the different ways of representing signed and unsigned integers; similarly there are several ways of encoding alphabetic characters as bits

Networks

Layering Models

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So they must be compatible on voltages, how bits are represented as electrical or optical signals, etc.

And they must agree on how to represent data as bits: recall the different ways of representing signed and unsigned integers; similarly there are several ways of encoding alphabetic characters as bits

And the same problem for all other kinds of data: how to represent that sound or that shade of blue?

Networks

Layering Models

And technical requirements we have of the network

Networks

Layering Models

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Such as do we make sure data arrived safely and didn't get lost or corrupted in transmission?

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Networks

Layering Models

And technical requirements we have of the network

Such as do we make sure data arrived safely and didn't get lost or corrupted in transmission?

And a lot of other problems that only become clear when you try to build a network

Getting this right all at once is very difficult

Networks

Layering Models

So how should we implement a network system?

Networks

Layering Models

So how should we implement a network system?

First we need a standard to follow

Networks

Layering Models

So how should we implement a network system?

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So how should we design a network standard?

Networks

Layering Models

So how should we implement a network system?

First we need a standard to follow

So how should we design a network standard?

The standard must address all the issues (and more) mentioned previously

Networks

Layering Models

This is too big a problem to be tackled all at once

Networks

Layering Models

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How about chopping the design into chunks, each chunk having a well-defined functionality?

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Note this is just the way we approach writing large programs

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Except we are not writing a program here, we are designing a standard

Networks

Layering Models

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How about chopping the design into chunks, each chunk having a well-defined functionality?

Note this is just the way we approach writing large programs

Except we are not writing a program here, we are designing a standard

So we slice the problem into nice, bite-size pieces, called *layers*

Networks

Layering Models

So what should the chunks be?

Networks

Layering Models

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A *layering model* for a system is a suggestion on how you might want to slice up the problem of designing it all

Networks

Layering Models

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An oft-misunderstood point is that a layering model is *not* a networking standard

Networks

Layering Models

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It is a recommendation on how you *approach the design* of the standard

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An oft-misunderstood point is that a layering model is *not* a networking standard

It is a recommendation on how you *approach the design* of the standard

After you have written the standard, you can then make implementations

Networks

Layering Models

So:

Networks

Layering Models

So:

- We pick a layering model

Networks

Layering Models

So:

- We pick a layering model
- We use this to guide us in making a standard

Networks

Layering Models

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Networks

Layering Models

So:

- We pick a layering model
- We use this to guide us in making a standard
- We use the standard to direct the implementations
- We can then use the implementations

Note that there will likely be several differing implementations

But, if it is a comprehensive standard, and *if all the implementations follow the standard*, they will interoperate

Networks

Layering Models

For networks, there are two main layering models in use: the ISO Open Systems Interconnection (OSI) Seven-Layer Model; and the Internet Four-Layer Model

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Layering Models

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The OSI model is widely used while the Internet model is not, despite closely mirroring the Internet standard