Evolving the Internet

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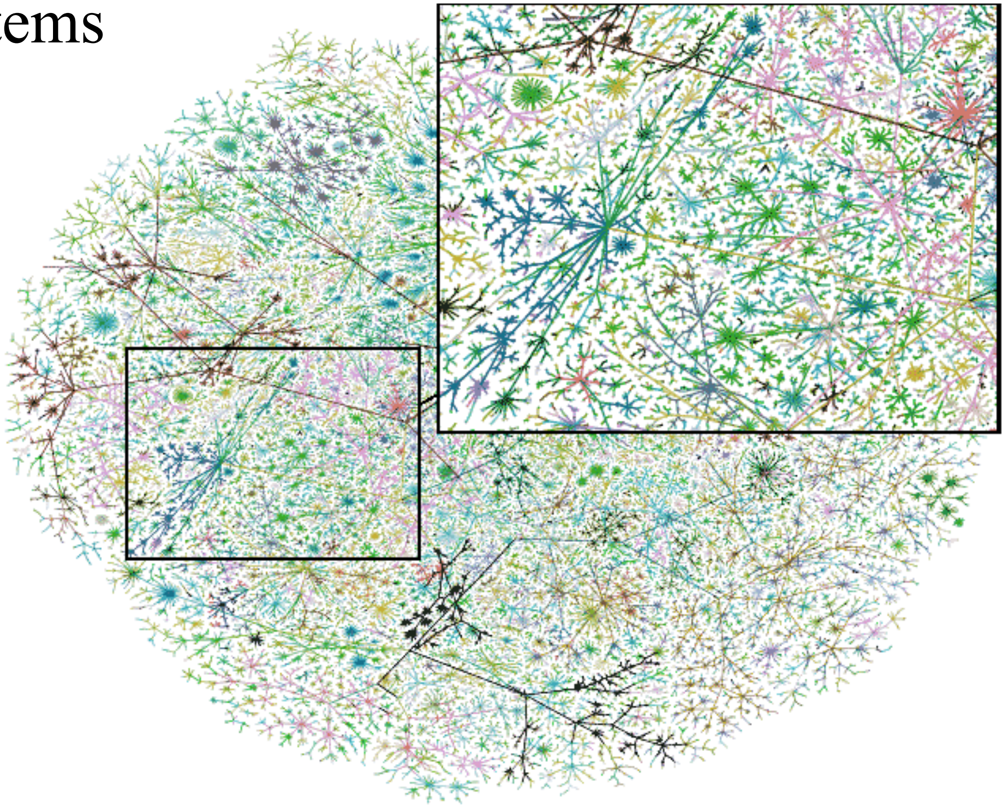
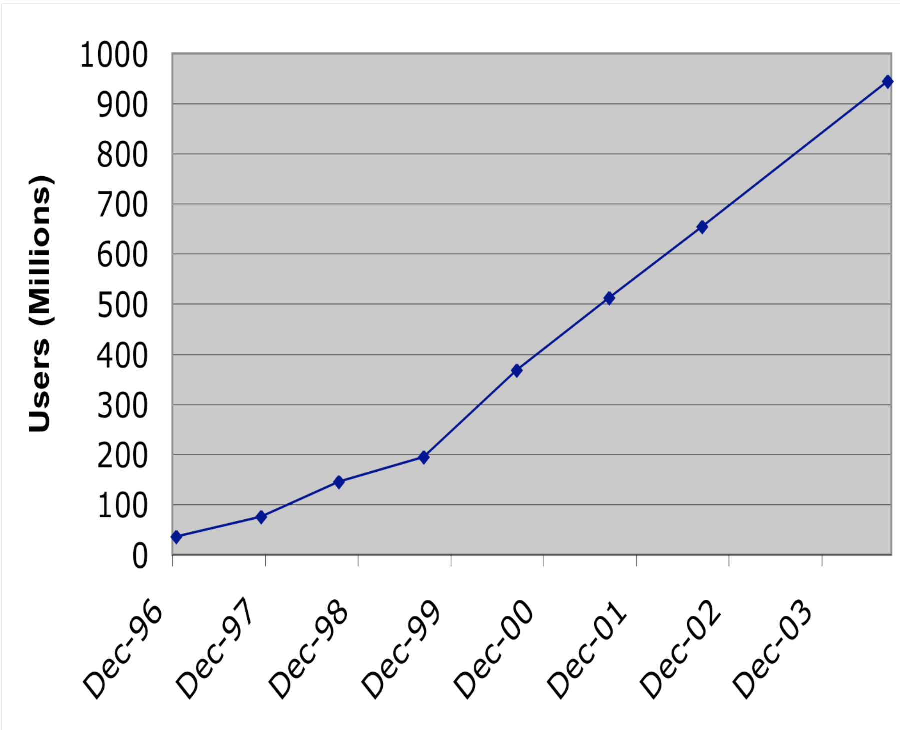
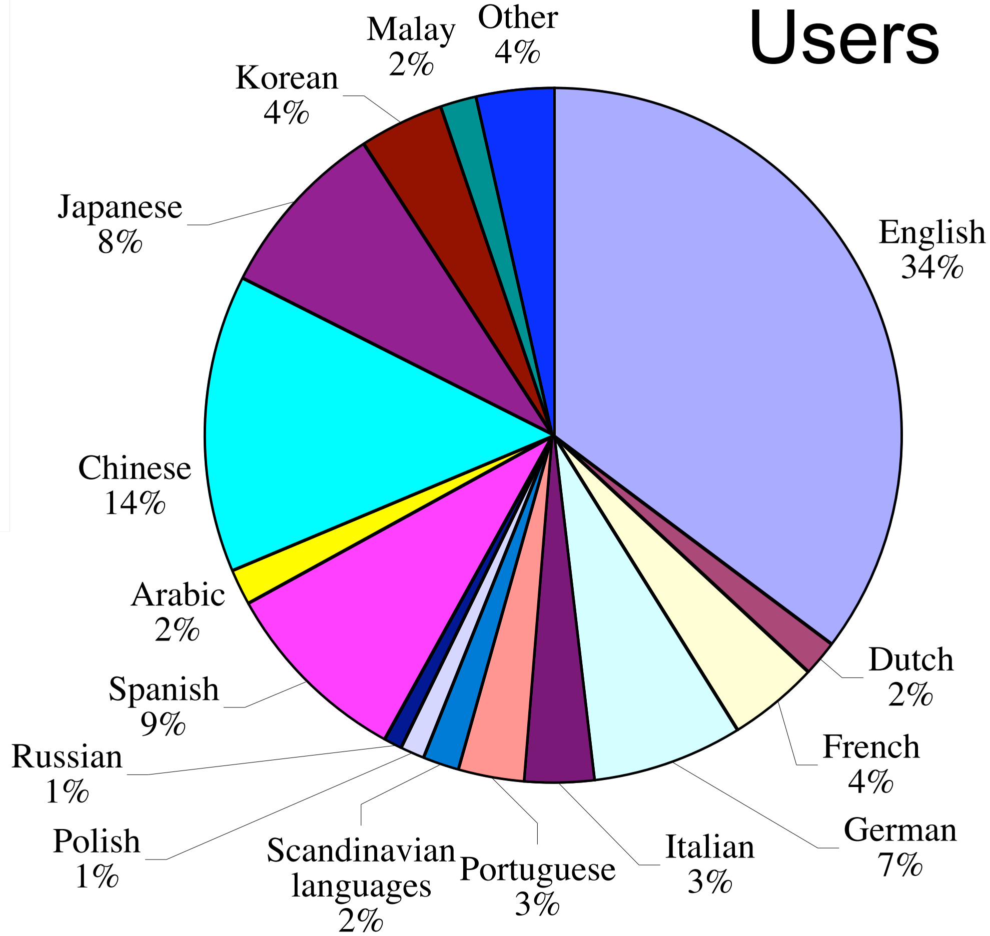


A Global Network



People on the Net

Languages of Internet Users



The net is a success!

- The problem:
  - In almost every way, the Internet only just works!

The net only just works?

It's always been this way:

1975-1981:

TCP/IP split as a reaction to the limitations of NCP.

1982:

DNS as a reaction to the net getting too large for hosts.txt files.

1980s:

EGP, RIP, OSPF as reactions to scaling problems with earlier routing protocols.

1988:

TCP congestion control in response to congestion collapse.

1989:

BGP as a reaction to the need for policy routing in NSFnet.

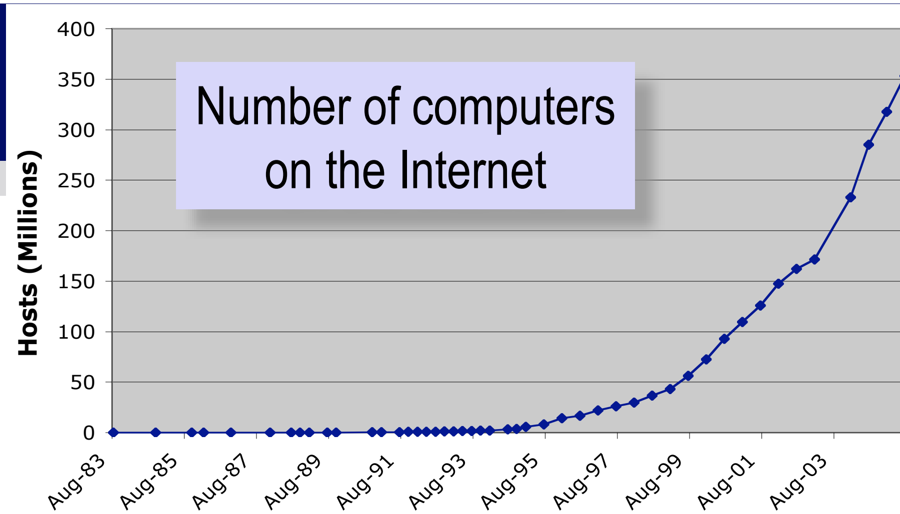
Changing the net.

- 1st Jan 1983.
  - Flag day.
  - ARPAnet switched from NCP to TCP/IP.
  - About 400 machines need to switch.

Sweden Changeover to Right Hand Traffic 1967

- As the net got bigger, it got *a lot* harder to change.

Before web...

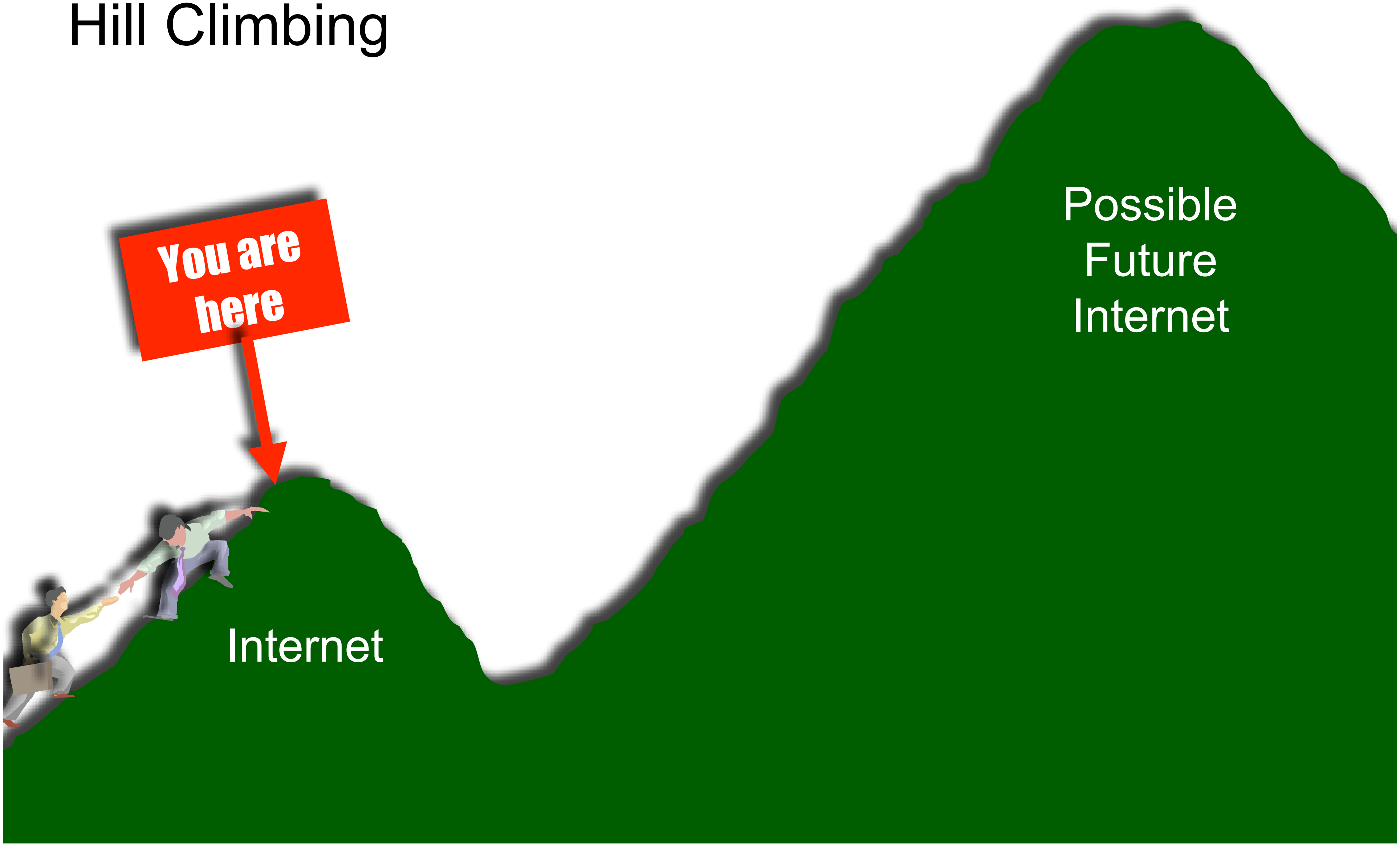


- Prior to the 1990s the Internet was primarily academic and scientific.
  - Common goals.
  - Low cost of failure.

- Then came the web, and commercialization of the Internet.
  - Exponential growth.
  - Financial costs of failure.
  - ISPs struggling to keep ahead of demand.
  - Huge innovation in applications.

Development Cycle

Hill Climbing



An Example:

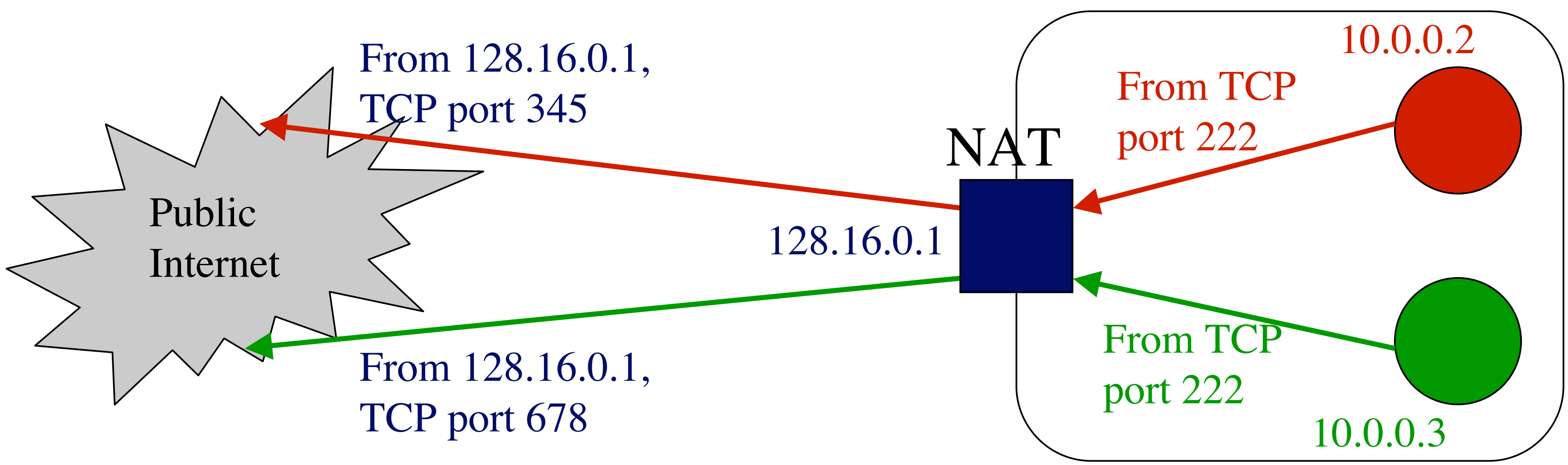
Running out of addresses...

- The current version of the Internet Protocol (IPv4) uses 32 bit addresses.
  - Not allocated very efficiently.
  - ~~MIT has more addresses than China.~~

    MIT + Interop trade show + Halliburton = China
- IPv6 is supposed to replace IPv4.
  - 128 bit addresses.
  - We don't need to be smart in address allocation.
  - How do we persuade people to switch?

Network Address Translators

- ~~Scarcity of addresses~~ *tiered pricing* has made addresses expensive.
- NATs map one external address to multiple private internal addresses, by rewriting TCP or UDP port numbers in flight.

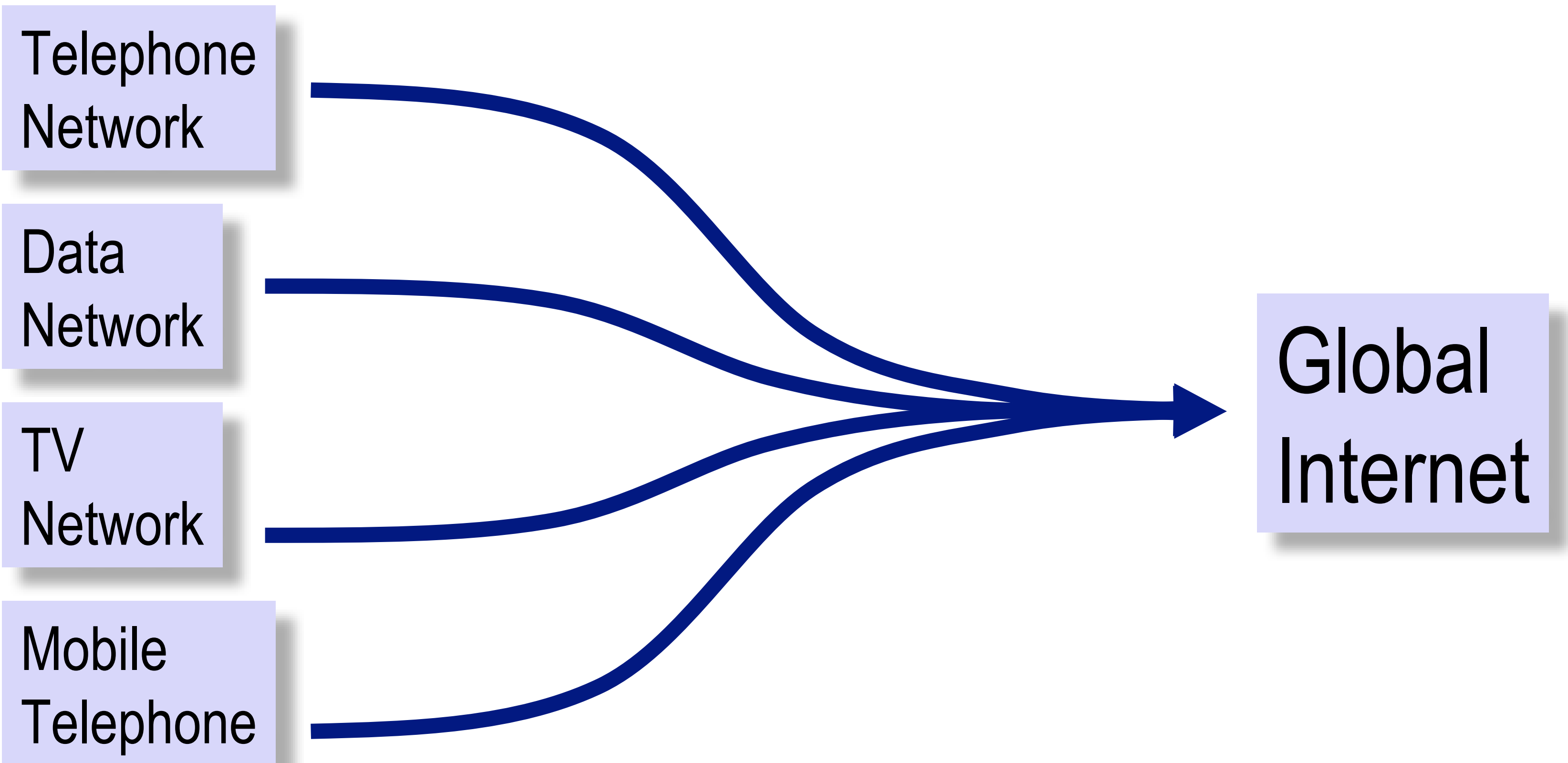


Network Address Translation

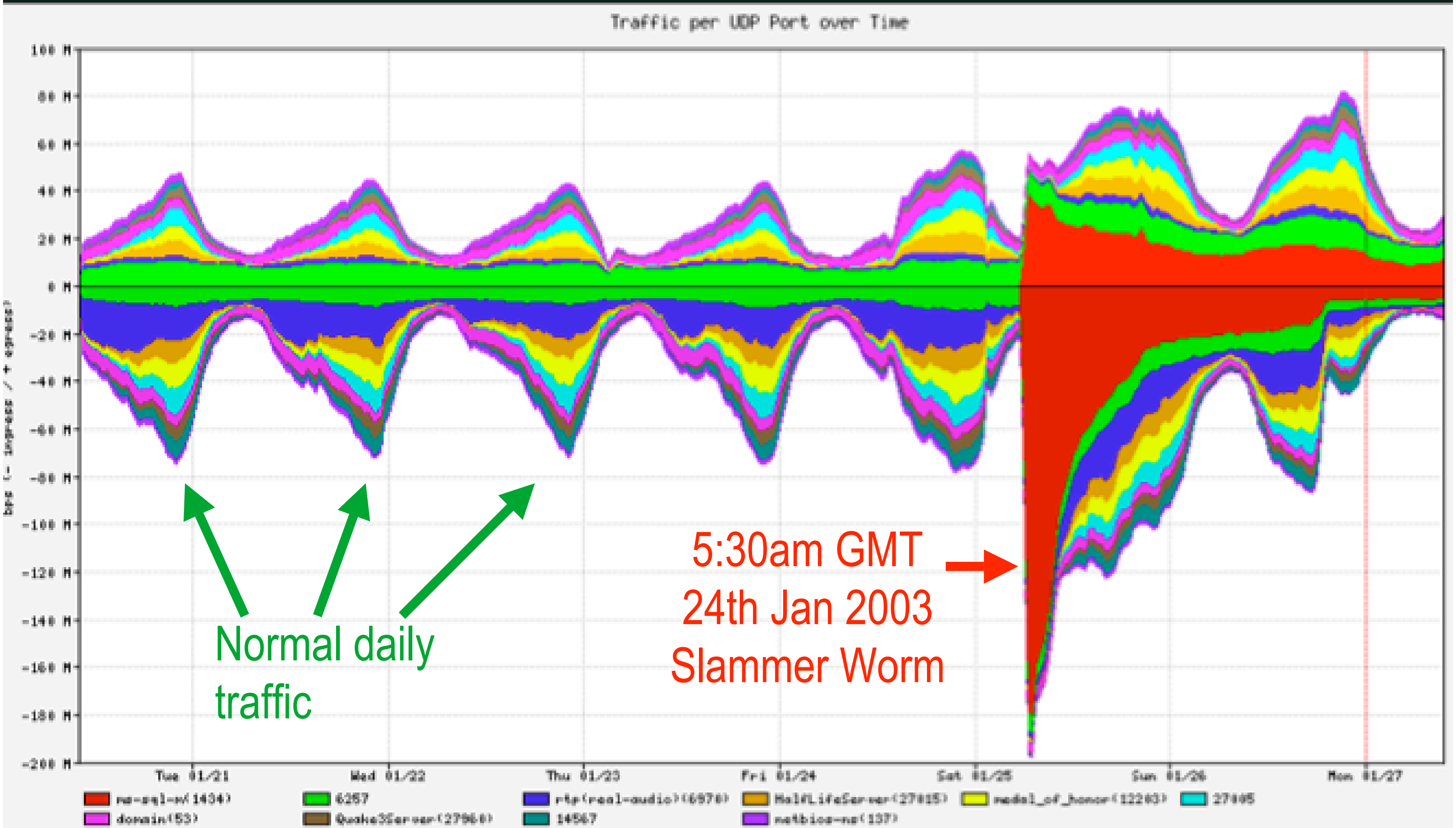
- Introduces asymmetry:
  - Can’t receive an incoming connection.
- Hard to refer to other connections:
  - Eg. SIP signalling causes the phone to ring.
  - On answer, set up the voice channel.

- Application-level gateways get embedded in NATs.
  - Can’t change the ends until you change the middle.
  - Middle won’t change til ends demonstrate a need.
  - It should be *easy* to deploy new *applications*!

Digital Convergence:
One Network Connecting Everyone



The Reality: Internet Worms, Viruses, and Denial-of-Service Attacks



The sky is falling!!!

- No.
- But we're accumulating problems faster than they're being fixed.
- There has been no significant architectural change to the network core in a decade.
- The consequences of failure are growing.

Imminent Architectural Problems

- Spam.
- Security.
- Denial-of-service.
- Application deployment issues.

Medium Term Architectural Problems

- Congestion control.
- Routing.
- Mobility, Multi-homing
- Architectural ossification.

Long Term Problems

- Address space exhaustion.
- Security on optically switched networks.
- How to connect billions of small devices.

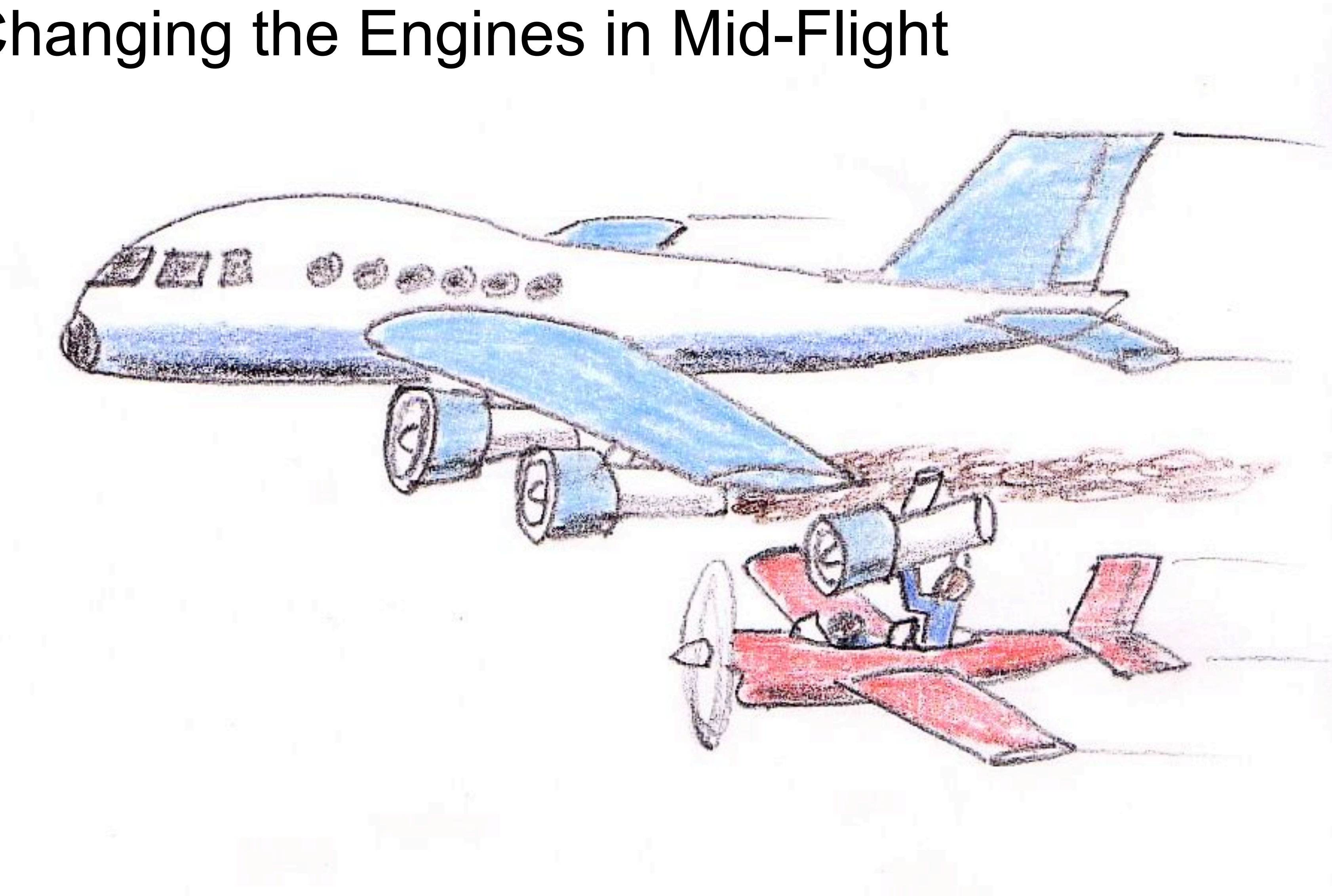
Key Challenge

Is it possible to change the Internet architecture in a planned way, so as to achieve long-term goals?

(or is it only possible to patch the pieces repeatedly until it gets too expensive and unreliable, and eventually something better comes along and replaces it?)

Evolving the Internet Architecture:

Changing the Engines in Mid-Flight



What can be done?

Basic **long-term** research.

- Industry players can't afford the long view.
- NSF's FIND programme.

Close the loop between research and *real-world* experiments.

- GENI, XORP open source router, Route Views/RIPE routing databases.

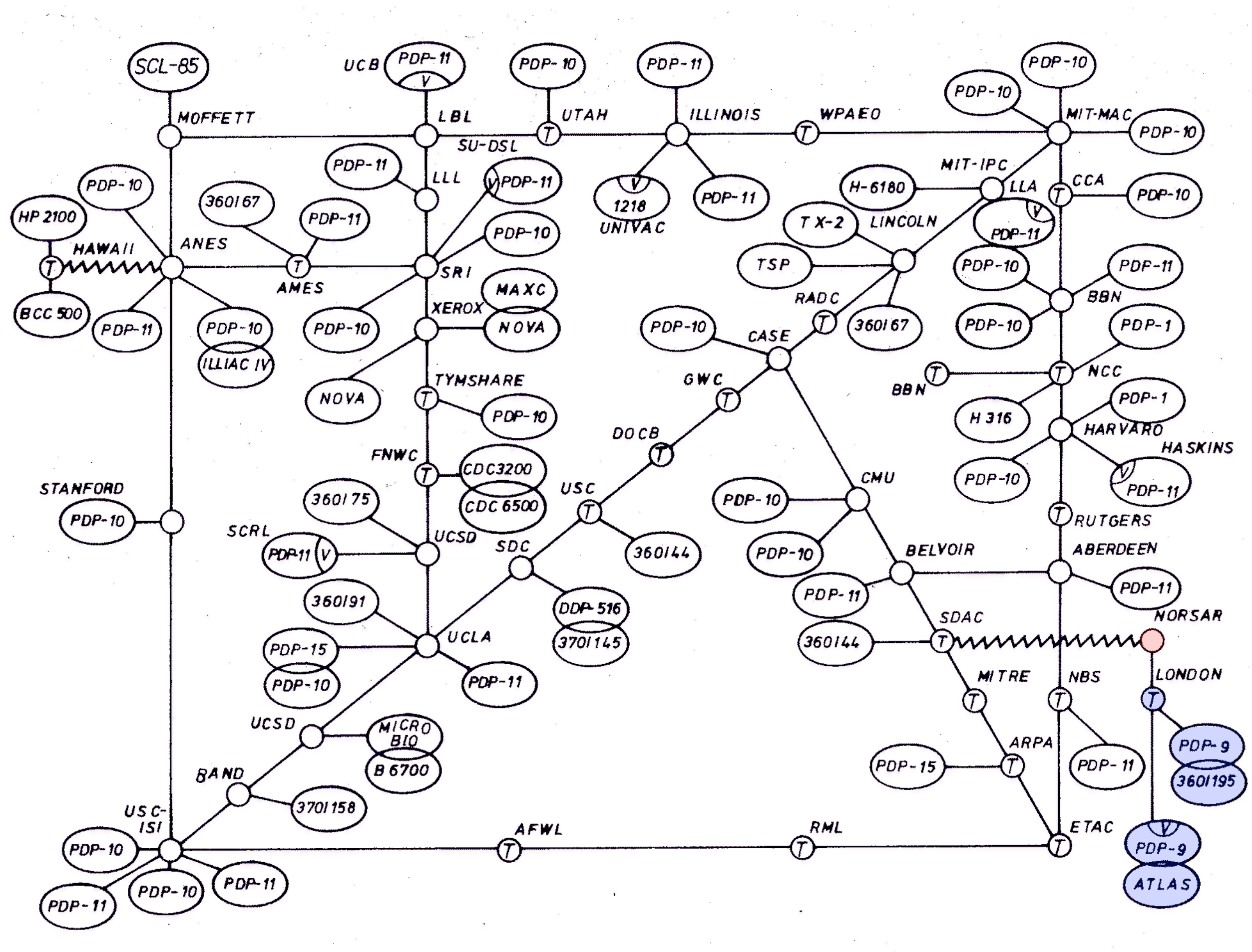
Coordination, coordination, coordination.

- Need to find a way to involve equipment vendors, ISPs, and researchers.
- CRN: Communications Research Network,
- IRTF Internet Congestion Control Research Group.

Our Research Goal

Make the Internet worthy of the trust that is being placed in it.

The End
(of the beginning)



ARPAnet, 1974