Internet Services: From Electronic Mail to Real-Time Multimedia

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Overview

- Internet: a new view on communication?
- Internet services
- World-Wide Web
- real-time (multimedia) services
- role of ATM in the Internet
- outlook

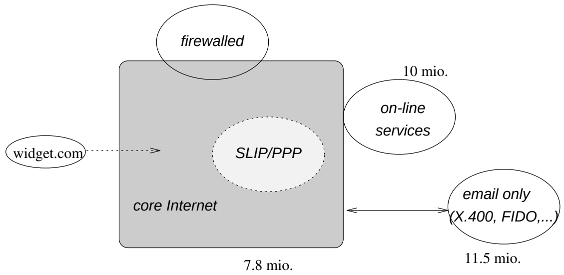
The (Over)Simplified View

conventional wisdom	Internet thinking
100 producers, 10^7 consumers	dog breeding club as publisher
home shopping	personal Web pages
video-on-demand	WWW
500 shopping channels	Internet-over-cable
fax	email
banking by phone	banking by secured WWW

The (Over)Simplified View, cont'd.

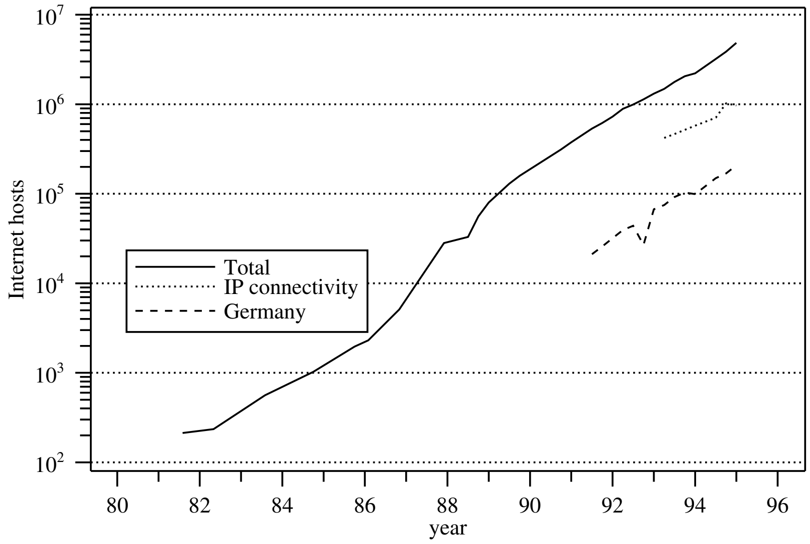
conventional wisdom	Internet thinking
transition to OSI	transition to IPng
videophone	MBONE
ATM PVC by fax	RSVP
private networks	global interconnection
set-top box	TV + PC
intelligent networks	dumb pipe, intelligent end systems
ISDN for voice	ISDN for Internet access

How Big is the Internet?



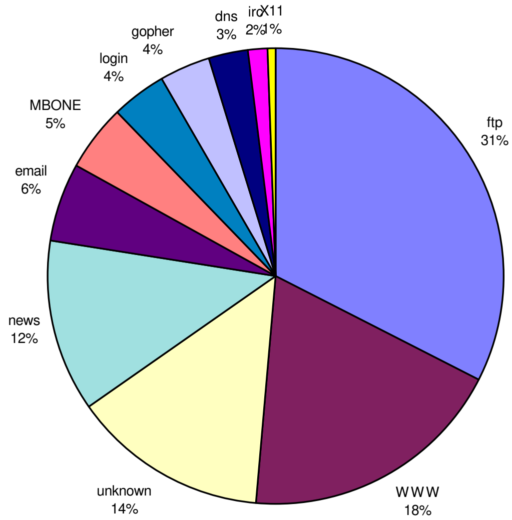
1. direct, permanent IP connectivity: minority
2. occasional IP connectivity (SLIP, PPP dial-up)
3. firewalled connectivity (hidden)
4. selected services: on-line services, Datex-J
5. email connectivity (FIDOnet, uucp, BITnet, . . .)
6. simply a registered name

How Big is the Internet?

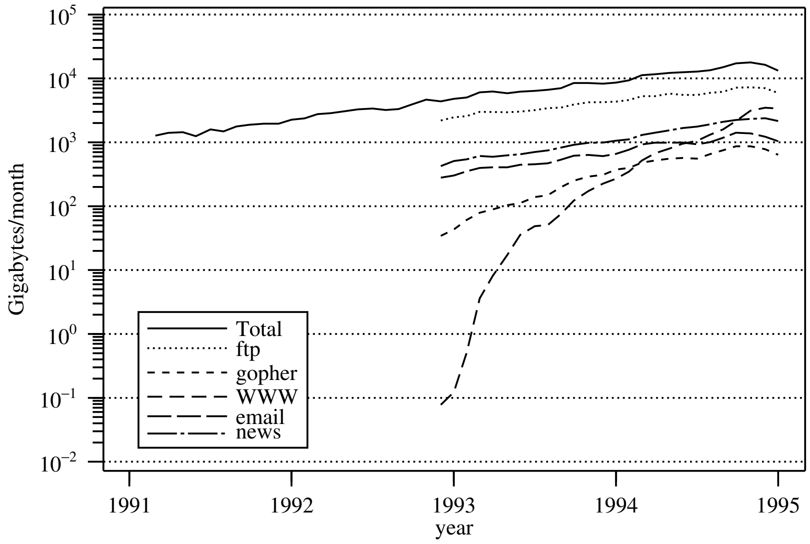


Internet Services

January 1995 NSFnet



Internet Traffic Report



WWW

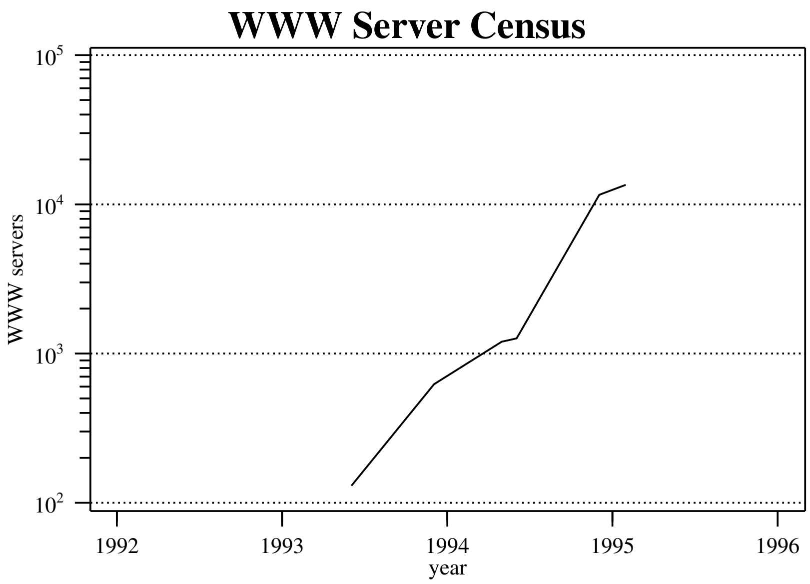
"World-Wide Web" = hypertext (HTML) (plus GIF, audio, MPEG, ...) + transfer protocol (HTTP) + links (URLs)

- HTML: trivial SGML document type: emphasis, headings
- HTTP: request-response file transfer
- URL: `http://nytimesfax.com/times.pdf`

server: delivers content

directory: URN → URL (not yet)

browser: retrieves/caches content



WWW in Progress

- authentication, charging (banks)
- authoring tools for word processors
- collaboration + WWW: “meet me on my home page”
- on-line services offering WWW

WWW Challenges

- real-time audio, video with interaction
- fire-and-forget helper applications → integrated applications
- user pull model → notifications
- HTML: neither full structure nor presentation
- HTML → tables, math, SGML
- style sheets for presentation control
- integration into applications (links to everywhere)
- URL → URN

Real-Time Services

- why integrating?
- audio and video characteristics
- problems of integrating audio & video with data
- network support for integration
- RTP: real-time transport protocol

Why bother?

- use existing workstations as audio/video terminals
- use existing LAN/WAN infrastructure
- efficiency:
  - true (LAN/WAN) multicast instead of MCUs and bridges – same application scales from two to hundreds of receivers
  - variable-bit rate (VBR) video, but interoperation with H.261 standards
  - audio silence suppression – important for large-scale conferences

Why bother integrating (cont'd)?

- added control functionality:
  - directory services
  - visual speaker indication
  - source selection at receiver
- integration of application-sharing and data applications, WWW

Disadvantages of packet audio/video

- no resource reservation → quality may suffer (but: RSVP)
- may push overloaded networks over the edge
- low frame rates for workstation video codecs
- hands-free speaking in infancy (echo)
- packetization overhead, delay
- operating systems ill-suited for real-time applications → single-user, no background load
- office environment: acoustics, lighting, ...

Characteristics of digital audio and video

	audio	video
rate (kb/s)	13 . . . 64 . . . 1500	200 . . . 1500 . . . 6000
loss tolerance	$\leq 5\%$	$10^{-5} \ldots 1\%$
packet size	small	large
traffic	interrupted CBR	VBR

One-way delay tolerance:

conference audio without echo cancellation: 40 ms

conference audio with echo cancellation: 150 ms

playback audio/video: $\geq$ 500 ms (“VCR response”)

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Integration of Real-Time and Data Traffic

- TCP (and TP4, . . .) not suited to carry real-time traffic:
  - flow control → window backoff and slow start
  - retransmission delay
- TCP backoff nice for making room for real-time traffic
- options:
  - low load, rely on data traffic backoff (but NFS doesn’t)
  - priorities at MAC/link level (starvation!)
  - bandwidth-allocating scheduling at link level
- transport protocols can’t help (except with set-up)!
- with low utilization, Ethernet will work

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Ethernet Audio/Video Capacity

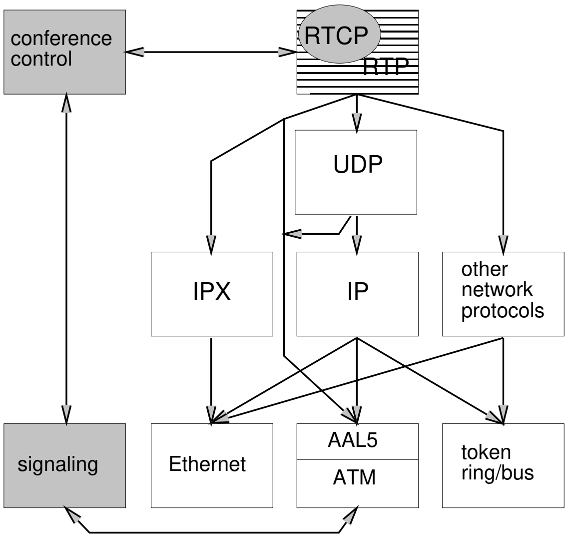
802.3 10Base-T Ethernet by Tobagi *et al.* (Infocom'94):

without data

delay	loss	64 kb/s	384 kb/s	1536 kb/s
20 ms	0.001	55 (35%)	14	4
20 ms	0.01	64 (41%)	17	5
100 ms	0.001	89 (57%)	18	5
100 ms	0.01	104 (67%)	20	5
bandw. limit		156	26	6

- effect of TCP backoff not considered
- 100Base-T: about 10 times capacity, as expected
- multicast "defeats" Ethernet switches

RTP: The Big Picture



RTP: Real-Time Transport Protocol

- only part of puzzle (→ scheduling, reservation, conference control)
- draft of Internet Engineering Task Force, AVT WG
- support for functions, but does not restrict implementation
- integrate with resource reservation (ST-II → RSVP)

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RTP: Functions

- segmentation/reassembly done by UDP (or similar)
- resequencing (if needed)
- loss detection for quality estimation, recovery
- intra-media synchronization: remove delay jitter through playout buffer
- intra-media synchronization: drifting sampling clocks
- inter-media synchronization (lip sync)
- quality-of-service feedback and rate adaptation
- source identification
- support for loss recovery (“video recorders”)

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RTP: Bridges, Translators, ...

bridge:

- several media stream $\rightarrow$ one new stream (new encoding)
- mixer: reduced bandwidth networks (dial-up)
- appears as new source

translator:

- single media stream
- *may* convert encoding
- protocol translation, firewall

RTP: Control Protocol

- typically, multicast by all participants
- frequency scales with group size ($\rightarrow 10^3$)

sender report: synchronization, loss estimation, ...

reception reports: QOS, adaptive applications

source description: name, email, location, ...

explicit leave: in addition to time-out

Audio/Video in the Internet: The MBONE

- MBONE $\equiv$ multicast backbone
- workstation-based overlay network
- needed until deployment of multicast-capable backbone routers
- IP-in-IP encapsulation, “tunnels”
- used mainly for conferences and seminars, weather maps, . . .
- limited capacity, resilience

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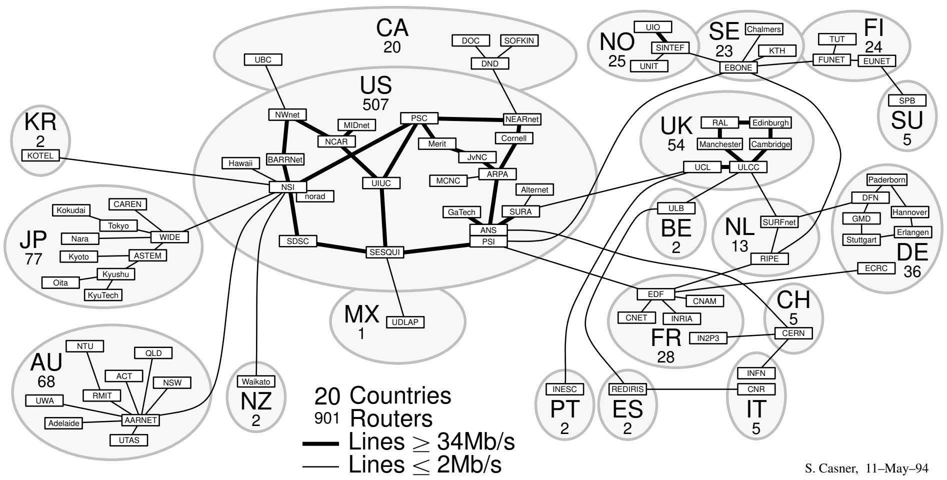
Major MBONE Routers and Links



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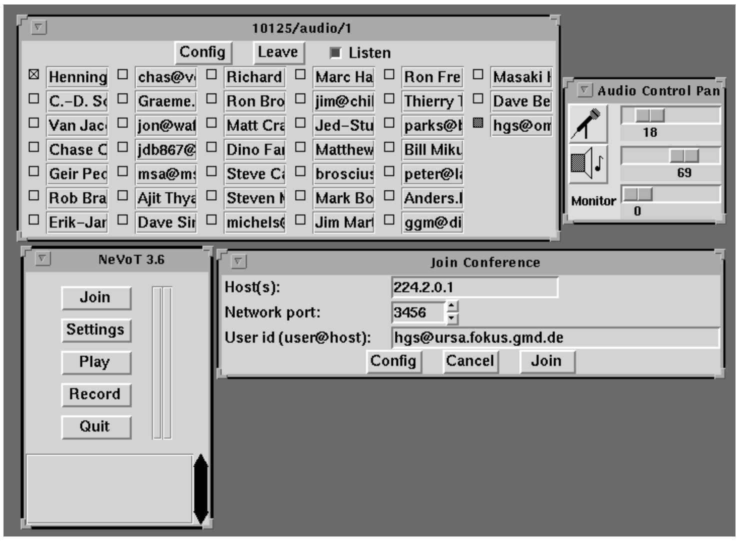
MBONE – Challenges

- high delay (tens to hundreds of ms): echo cancellation?
- fragile to accidental use → pruning, hierarchical multicast
- low bandwidth → router, switch support
- scaling to thousands of sessions, participants

Building CSCW Applications



Internet as “Intelligent Network”

’Intelligent network’ functionality

- PBX-like services: easy with packets, intelligent nodes
- universal telephone number: email address
- local server: `hgs@fokus.gmd.de` →
  `hgs@informatik.tu-chemnitz.de` →
  `kivs007@daisy.informatik.tu-chemnitz.de`

Whither ATM?

Two directions for internetworking:

- ATM as pipe with custom rate (cross connect)?
- ATM/Sonet/Ethernet/wireless/. . . – IPng – transport – application
- fiber – ATM – AALx – application

ATM: Some Questions

- QOS is (currently) a myth
- circuit setup times (even without PVC-by-fax)
- multiplexing requires large buffers
- VCs: scarce resource?
- VCs for 1 kb/s remote monitoring – if not, no integrated network!
- ATM for wireless? ISDN? modems? lightswitches?
- currently, no security
- UNI vs. NNI (cp. Internet model: host $\approx$ router)?
- setup to 10,000 multicast sites?
- crash recovery by application? rerouting?
- desk telephone with ATM connector?

Internet Lessons

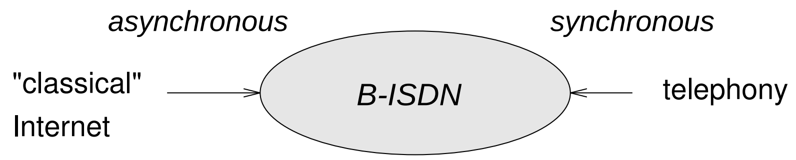
- flat fee encourages use, new applications ($\leftrightarrow$ ATM in Europe)
- strong academic involvement
- US: competitive backbone, regional; not yet local
- low cost of entry: standards free, 20/80 solutions
- "rough consensus, working code"
- 5 layers instead of 7
- text-based protocols instead of ASN.1: email addresses, URLs
- not everybody will be on fiber/ATM all the time, for a long time $\rightarrow$ diversity of media, speeds, services
- end-system debuggability (ping, traceroute, RTP QOS, . . .)
- end system intelligence ($\rightarrow$ frame relay, ATM)

Internet in Germany

- very expensive for moderate bandwidth (T1: 300,000 DM vs. $12,000)
- X.25: the application killer – harbinger of ATM?
- little commercial presence
- Datex-J as entry?
- Germany underdeveloped: $ GNP/Host (July 1994):

Iceland	1.67
Finland	2.62
U.S.	2.79
Chile	8.24
Germany	10.03
Japan	43.38

Internet to GII – Technology



- still US-dominated (largely by Europe NIH + OSI syndrome)
- flat-fee → QOS-based charges
- large number of “carriers”: reliability? accountability?
- every lightswitch with an IP address?
- disappearance of network layer as unifying abstraction?
- text-based protocols: kludges, speed, internationalization
- everybody behind a “firewall”?

Internet to GII – Cultural

- PTTs as providers?
- "spamming", content control, cultural issues
- privacy vs. Internet as BCCI II
- every mom-and-pop store with international presence
- Internet: replace with "real thing" or evolution?