

# The Internet: Hot or Cold?

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1

# The Internet: Hot or Cold?

- **A Brief History Lesson**
- IP as Interconnect
- Internet vs. IP
- Business Models
- Regulatory Challenges

2

## The Internet: *My* Definition

- ◆ The set of machines and services accessible through the globally administered IP address space
- ◆ Accessible means “Always On”
- ◆ Let’s ignore URLs, DNS, Firewalls, etc. for this talk

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3

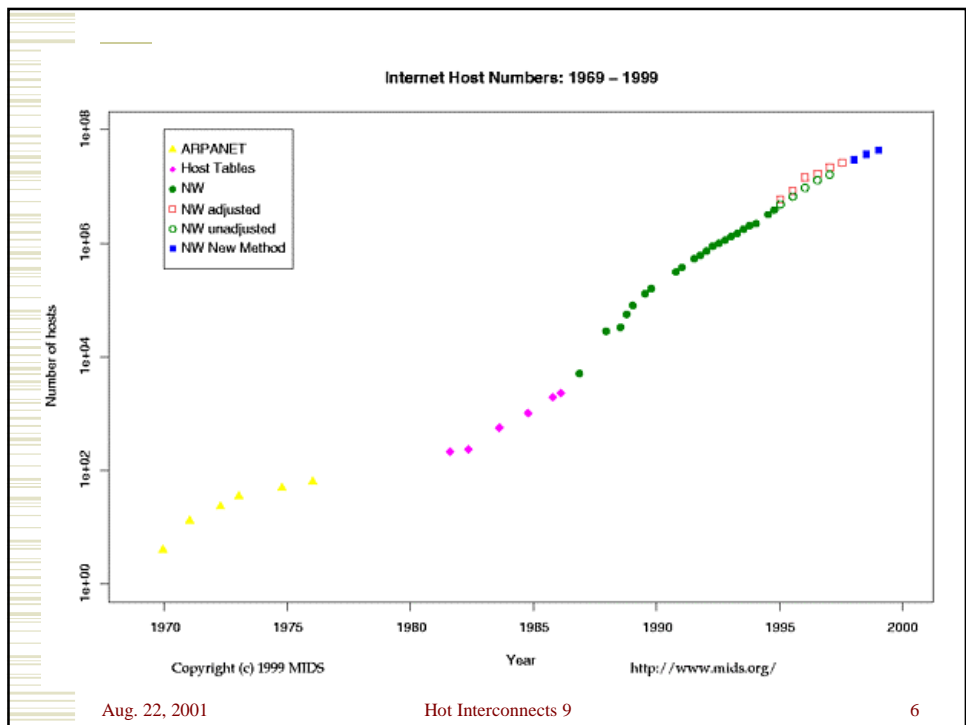
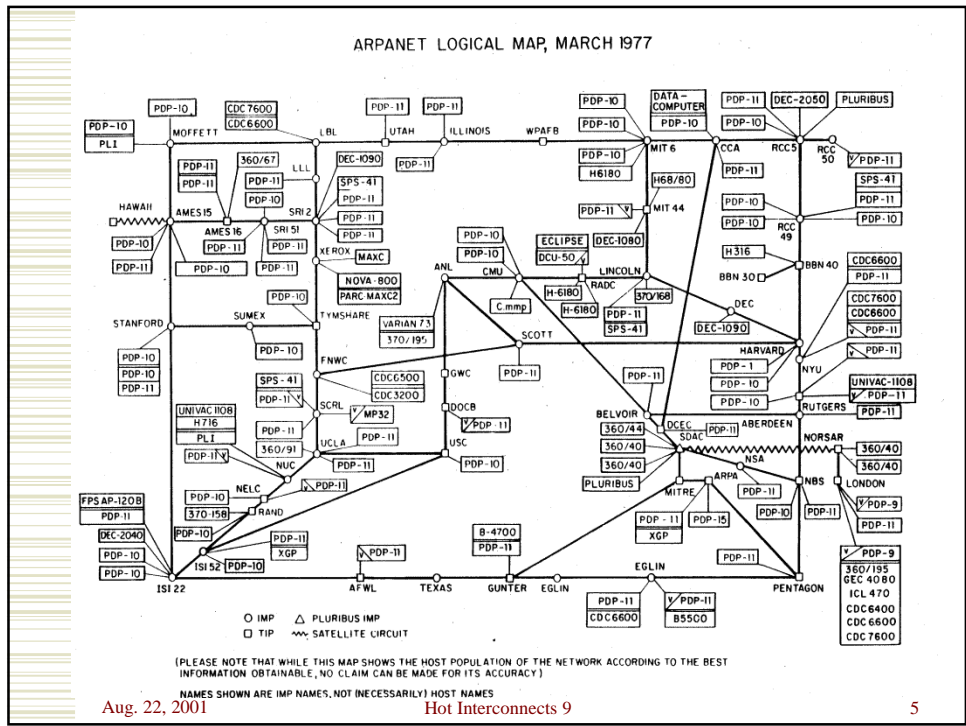
## IP History

- ◆ 1972: Kahn proposes ‘Interneting’
- ◆ 1977: 16 network numbers
- ◆ 1978: Cerf proposes ‘Catenet’ model
- ◆ 1981: IPv4: RFC 791, 43 networks assigned
- ◆ 1983: ARPANET transition to IP & TCP
- ◆ 1995: Windows 95 released, IPv6 defined
- ◆ Today: 120M hosts, 435M users

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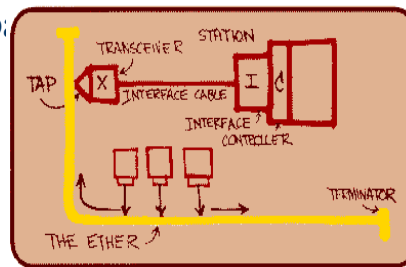
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# Ethernet History

- ◆ 1973: Metcalfe et al – 2.94Mb
- ◆ 1980: DEC, Intel, Xerox Blue Book 10Mb
- ◆ 1983: IEEE 802.3
- ◆ 1990: 10Base-T, Kalpana
- ◆ 1995: 100Mbps
- ◆ 1998: Gigabit
- ◆ 2001?: 10G Ethernet



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# Router History

- ◆ 70s: unique gateway implementation for each network type pair
- ◆ Early 80s: IP forwarding & RIP in BSD UNIX
- ◆ Late 80s: Cisco & router “appliances”
- ◆ Early 90s: real router hardware
- ◆ Late 90s: routing ASICs, performance explosion



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## Switch History

- ◆ 70s: “Ethernet – A Distributed Switch”
- ◆ Early 80s: LANs take off
- ◆ Mid 80s: Bridging between LANs
- ◆ Late 80s: 10Base-T & hubs
- ◆ 1990: Kalpana EtherSwitch
- ◆ Mid 90s: ASICs + performance explosion
- ◆ Late 90s: “Layer 3” switches

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## Switch vs. Router

- ◆ Switches assume high BW, low delay
- ◆ Routers accommodate any BW, high delay
- ◆ TCP needs  $BW \cdot \text{delay}$  buffers in worst case
  
- ◆ Routers = Congestion = Buffers + QoS
- ◆ Switches = Cheap! (esp. w 802 flow control)

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11

## The Ideal Interconnect

- ◆ High bandwidth
- ◆ Low latency
- ◆ No loss, no re-ordering
- ◆ Secure – authenticated & private
- ◆ QoS
- ◆ Easily reset

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12

## Internet as Interconnect

- ◆ High bandwidth
- ◆ Low latency
- ◆ No loss, no re-ordering
- ◆ Secure
- ◆ QoS
- ◆ Easily reset
- ◆ No
- ◆ No
- ◆ Hah!
- ◆ Wrong!
- ◆ Not yet/ever?
- ◆ Never reset

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## The Ideal Application

- ◆ Variable bandwidth
- ◆ Latency tolerant
- ◆ Loss, ordering tolerant
- ◆ Secure
- ◆ QoS tolerant
- ◆ Soft state
- ◆ The Internet is breeding 'killer' applications

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## Failure Domains

- ◆ System interconnects typically assume a single failure domain: master/slave or common reset
- ◆ Networks assume disjoint failure domains: your insanity won't spread to me
- ◆ How big *should* a failure domain be?

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## IP as Network

- ◆ IP started for inter-networking
- ◆ Assumes little from underlying network, extends anywhere
- ◆ As IP dominates, L2 networks commoditize
- ◆ IP becomes the network, L2 becomes links
- ◆ L2 convergence
  - Broadcast -> Ethernet
  - Point-to-Point -> PPP
  - NBMA/Clouds -> Gone!

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## The Zen of IP

- ◆ IP assumes very little of underlying networks
- ◆ IP doesn't get in the way of new applications
  - Telnet -> Email -> Web -> Napster -> ???
- ◆ Applications assume very little from IP
- ◆ By not assuming reliability, it comes.

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## Out There to In Here

- ↑ Inter-planetary IP – Cerf
- ↑ Global IP - Internet
- ◆ Original IP – Inter-network
- ↓ Native IP networks
- ↓ System Area IP
- ↓ In-System IP
- ↓ On-Board IP
- ↓ On-Chip IP?

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## Failure Domains

- ◆ As complexity increases, reliability decreases
- ◆ Software is *never* fully specified & tested
- ◆ Networks *usually* prevent “domino” failures
- ◆ As chips hit 100M transistors, should we consider multiple domains per chip?
- ◆ Not hard failures – soft insanities

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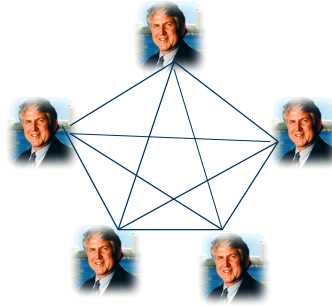
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20

## Metcalfe's Law

- ◆ The value of a network grows as the square of the number of users

- ◆  $M_N = cU_N^2$



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## Too Many Networks

- ◆ There are way too many disjoint IP networks in the world, driven by:
  - Administrative concerns
  - Security concerns
  - Lack of public address space
  - Lack of vision
- ◆ IP without the 'T'

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## The Dying LAN

- ◆ Everyone on the LAN wants Internet access
- ◆ Remote and Mobile users use Internet VPNs
- ◆ Servers are moving to IDCs
- ◆ Firewalls, routers, switches are being managed by MSPs
- ◆ 802.11 WLANs aren't used as LANs
- ◆  $M_{\text{LAN}} \ll M_{\text{Internet}}$

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## The Big Networks

- ◆ PSTN > 1 billion *lines*
- ◆ Cellular approaching 1 billion *users*
- ◆ Internet: 120M *hosts*, 435M *users*
  
- ◆ But, Internet easily extends over PSTN
- ◆ Soon to extend over cellular

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## The Coming Avalanche

- ◆ As many new cell users this year as total Internet users
- ◆ Cell phones becoming “Internet” capable
- ◆ DoCoMo I-mode: 0 to 27M users in 2.5 yrs, world’s 2<sup>nd</sup> largest “ISP” – but no IP!
- ◆ GPRS and 3G require IP to handset
- ◆ Not enough IPv4 for all this; Mobile-IP doubles it!

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## The V6 Internet

- ◆ IPv6 is deployable now, but is classic chicken & egg problem
- ◆ Mobile/3G will push IPv6 over the edge
- ◆ V6 Internet is easy if you have V4
- ◆ V6 Internet is easier if you don’t
- ◆ V6 covers V4 like V4 covers PSTN
- ◆ Metcalfe’s Law means V6 will win

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## IP vs. Internet

- ◆ Everyone believes in IP now, even if they don't know what it is
- ◆ Carriers view the Internet as a source of technology or users, not as their principal service
- ◆ They build non-IP or private IP nets and avoid the Internet
- ◆ But the Internet is just the interconnection of carriers' networks!

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## Internet Avoidance Syndrome

1. Assume the Internet is unmanageable chaos
2. Go build a separate network
3. Discover that users, traffic, and applications are still defined by the Internet!
4. Repeat until bankrupt

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## Embracing the Internet

1. Assume the Internet is *the* network
2. Build Internet centric apps & services
3. When required, engineer critical paths
  - a. Get SLAs from ISP, - or -
  - b. Build your own piece of the Internet with the SLAs you need
4. *Use the Internet, or Be the Internet!*

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## Hot Stuff!

- ◆ IP enabled the Internet
- ◆ The Internet drives IP everywhere
- ◆ Peering, i.e. inter-networking, is fundamental to the Internet
- ◆ So the Internet is HOT! Right?

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## BellHeads vs. NetHeads

- ◆ My Network
- ◆ My Users
- ◆ My Services
- ◆ IP is a service
- ◆ Peering/Roaming at a cost
- ◆ Regulated Assets
- ◆ Change is Bad
- ◆ Well funded
- ◆ Proven business models



- ◆ One Internet
- ◆ Any Users
- ◆ Any Services
- ◆ IP is a transport
- ◆ Peering/Roaming assumed
- ◆ Assets?
- ◆ Change is Good
- ◆ Poorly funded
- ◆ “Searching...”



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## Carrier Types

- ◆ Facilities Based vs. Services Based
- ◆ Regulated vs. Unregulated
- ◆ Access Carriers
  - ILECs – regional monopolies
  - Cable – local monopolies
  - Satellite – Oligopoly
  - Cellular - Oligopoly

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## Facilities Based Carriers

- ◆ Traditionally, the local and long distance telephone companies were considered FBCs
- ◆ Wall Street likes FBCs
- ◆ In long distance, competition and fiber glut have tarnished the segment
- ◆ Now FBC means Regulated Carrier

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## Dialup

- ◆ Free local phone calls created the consumer ISP
- ◆ ILECs lost control of the user & services, but still paid a lot for the network buildout
- ◆ AOL - huge ISP, no network!
- ◆ RBOCs – bigger network, no revenue!

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## DSL

- ◆ ILECs get revenue for DSL
- ◆ CLECs starved out
- ◆ Trying hard not to lose control of users
- ◆ Some control of services, e.g., SBC with Prodigy

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## Cable

- ◆ Historically, cable operators lost money but content providers made lots
- ◆ No common carriage requirement, so closed system
- ◆ Alliances – AT&T with @Home, AOL with Time-Warner
- ◆ Owning users, services, & networks

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## Cellular

- ◆ WAP, GPRS, 3G efforts all oriented towards keeping user under control of carrier
- ◆ Make some money on voice, but lots of money on hit services – ringtones, SMS, etc.
- ◆ DoCoMo's I-mode like AOL – semi-open services

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## The Peering Problem

- ◆ Bandwidth may be cheap, but connectivity is very expensive
- ◆ Services pay for the networks
- ◆ Peering lets *my* users go to *your* services; if *your* users come to *my* services, how will I bill them?
- ◆ Examples – Voice, Roaming, SMS

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## The Frozen Interconnect

- ◆ Carriers all want to be ‘more than a bit pipe’, e.g., the ‘next AOL’
- ◆ But restricting services means they’re LESS than a bit pipe; services tend toward mediocrity
- ◆ With open services, who pays for the network?

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## Is the Internet Regulated?

- ♦ Backbone – not regulated, but oligopolistic via peering & address allocation requirements - origin in NSFNET spinoffs
- ♦ Access – there are no IP access networks!
  - PSTN
  - Cable
  - Cellular
  - Satellite

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## Feast and Famine

- ◆ Without regulation – too many providers, finite demand, commodity services – financial disaster & service disruption
- ◆ Digital divide – everyone targets top 1% of users or locales, everyone else waits
- ◆ DSL ISPs, fiber carriers, WLAN ISPs

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## Critical Infrastructure

- ◆ The Internet is becoming critical infrastructure
- ◆ The base conditions of the Internet were *entirely* determined by regulation
- ◆ Pure capitalism won't produce a stable solution
- ◆ PSInet, Northpoint, etc. vs. P.G.&E. – are your lights on?
- ◆ “Where were you when the Internet went out?”

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44

## Info Highways?

- ◆ Information Highway? Real highways are publicly funded, controlled, used
- ◆ Interconnection is the whole point
- ◆ Societal benefit is huge
- ◆ No model for capitalism to work



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## ISPs vs. ITPs

- ◆ We need to cleanly separate Internet Service from Internet Transport
- ◆ Encourage, regulate, & certify Internet transport
- ◆ Award local access monopolies *by technology*, require minimum performance, common carriage and no bundled services
- ◆ Peering between ITPs should be carefully monitored & funded
- ◆ Just like a utility

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## CarterPhone

- ◆ 1968 decision required Ma Bell to allow customers to connect their own equipment to PSTN
- ◆ Enabled profusion of data applications
- ◆ What about other nets? Cable – no, DSL – maybe, Cellular – no, Satellite – no, DTV – a mess
- ◆ Lock on equipment & distribution by carriers stifles innovation

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47

## CarterService?

- ◆ We need to require ITPs to provide equal access to ISPs – cable needs to be a common carrier ITP
- ◆ Not just Web services, but anything that might evolve above IP
- ◆ This is a normal phase of evolution for “networks” – railroad, telephone, highway, ...

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48

## Conclusion

- ◆ The Internet is too important to leave to ...
- ◆ Start with certified access? **1TrueIP<sup>SM</sup>**
- ◆ This is just IP, there's lots of other battles ahead
- ◆ When will this happen?
- ◆ What can *you* do?