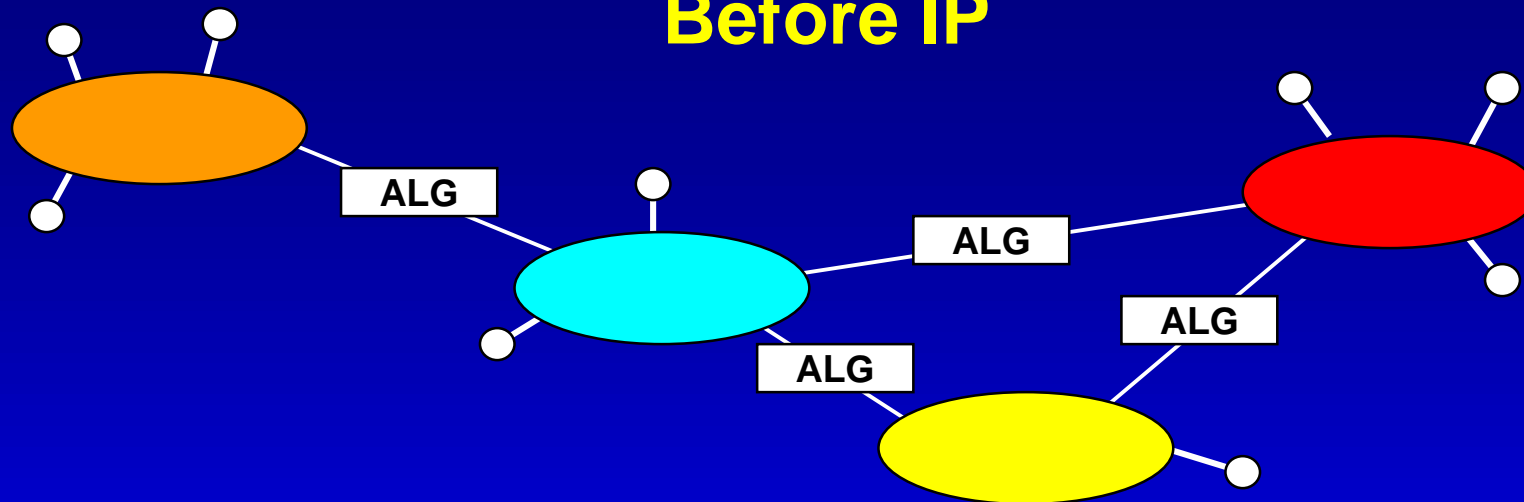# IPv6: Addressing the Future

Steve Deering
deering@cisco.com

Global IPv6 Summit, Madrid
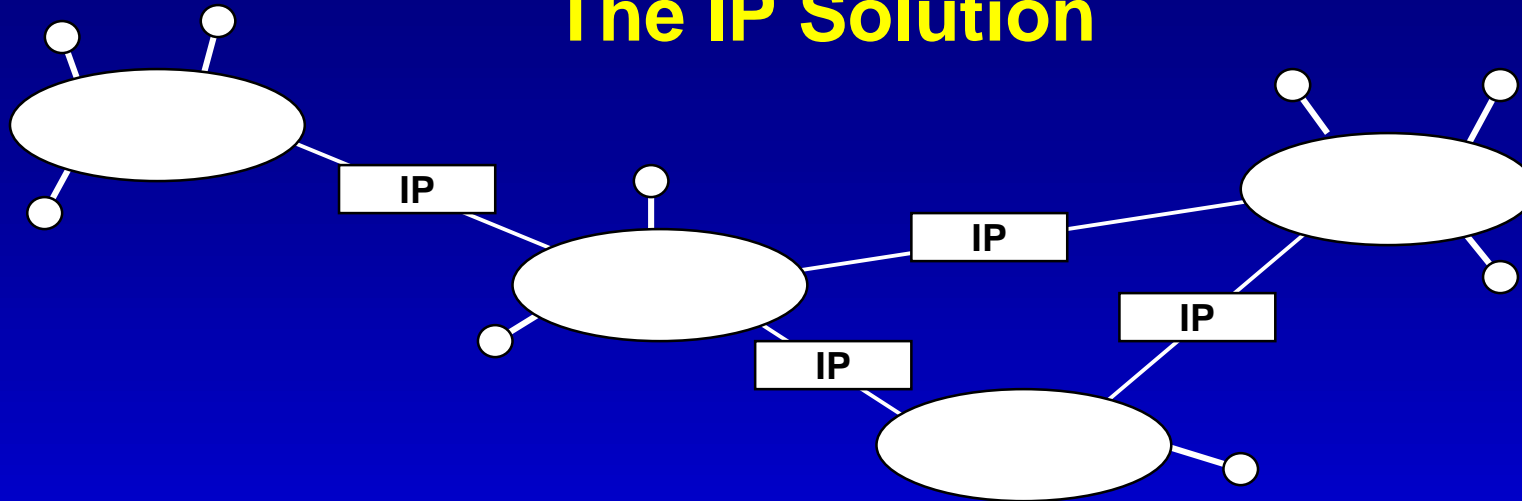January 29, 2001

The Past

Before IP

diverse networks joined by application-layer gateways
— inevitable loss of some functions
— difficult to deploy new internet-wide applications
— hard to diagnose and remedy problems
— stateful gateways inhibited dynamic routing around failures

no global addressability
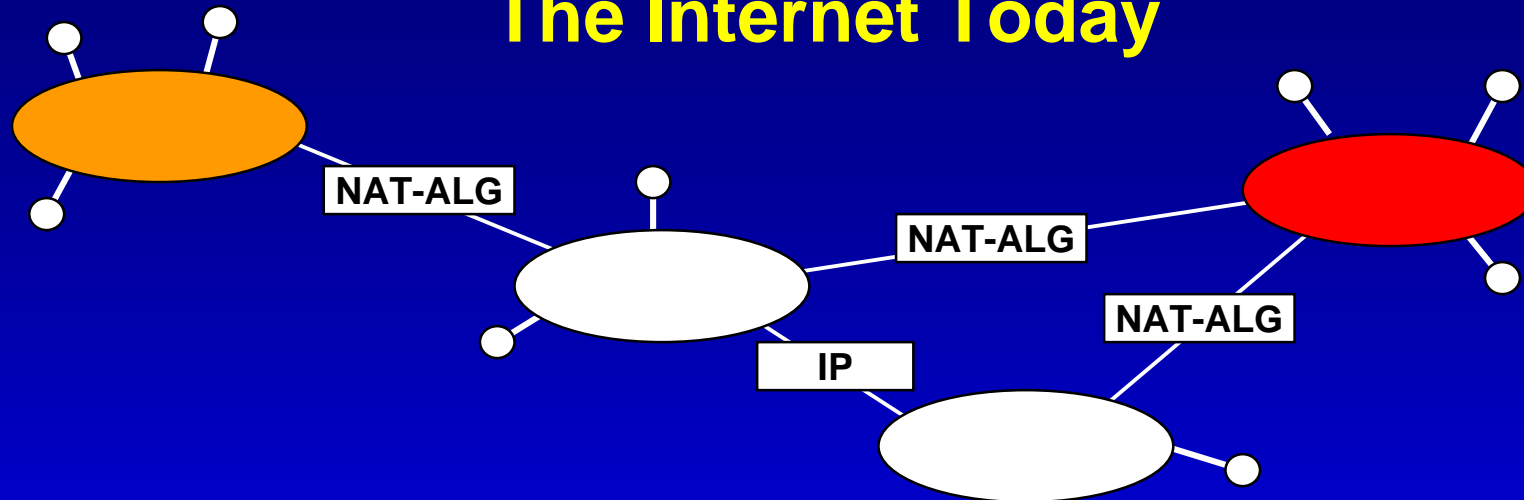— ad-hoc, application-specific solutions

3

The IP Solution

IP routers & global addresses
- —simple, application-independent, least-common-denominator network service: best-effort datagrams
- —stateless gateways could easily route around failures
- —with application-specific knowledge out of the gateways:
  - *anyone* could deploy new, internet-wide apps and services
  - Internet became a platform for rapid, competitive innovation

The Internet Today

NAT-ALG

NAT-ALG

NAT-ALG

IP

network address translators and application-layer gateways
- —inevitable loss of some functions
- —difficult to deploy new internet-wide applications
- —hard to diagnose and remedy problems
- —stateful gateways inhibit dynamic routing around failures

no global addressability
- —ad-hoc, application-specific (or ignorant!) solutions
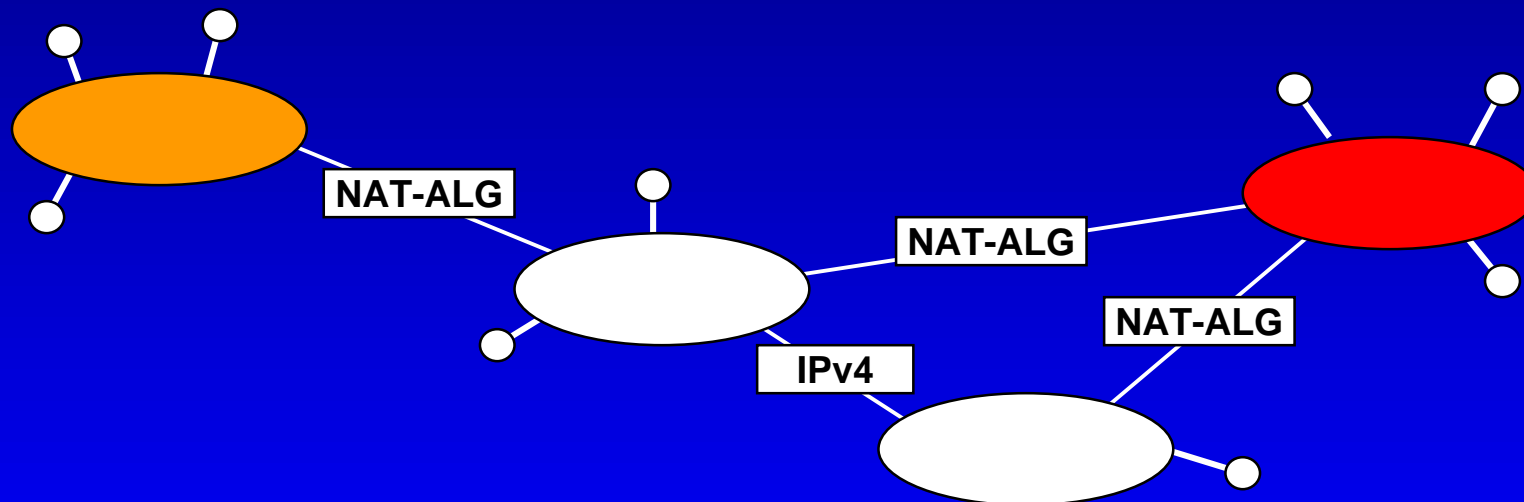
The Future

The Probable Future

- billions and billions of new Internet devices

- billions and billions of new Internet users

- Internet available everywhere, all the time
  (wired, wireless, mobile,…)

- convergence of all communication on the Internet
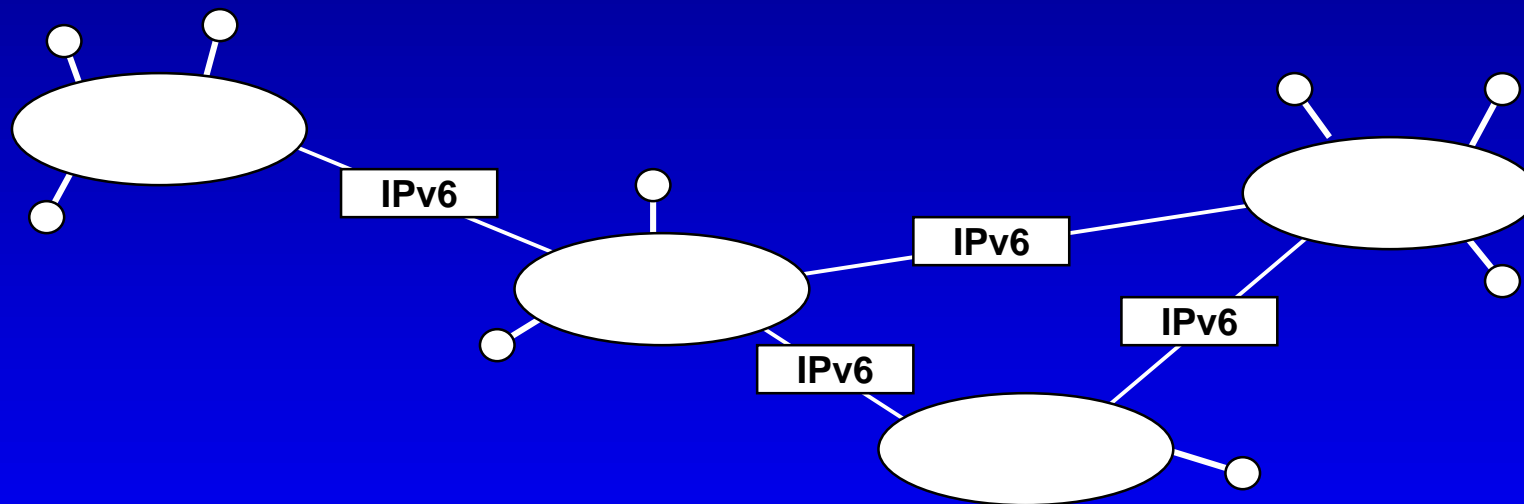 (business, personal, entertainment, public services,…)

The Unknown Future

continued degradation of the Internet model with IPv4?

- more complex and volatile network service
  - => lower performance, less robust, less secure, less manageable

- more centralized control over new applications and services
  - => significant barrier to innovation and growth

The Unknown Future

…or restoration of the Internet model with IPv6?

- simple, stable network service
  => higher performance, more robust, more secure, more manageable

- enabling anyone to provide new applications and services
  => allowing rapid innovation and growth

IPv6 Today

Standards

- core IPv6 specifications are IETF Draft Standards
  => well-tested & stable
  - IPv6 base spec, ICMPv6, Neighbor Discovery, PMTU Discovery, IPv6-over-Ethernet, IPv6-over-PPP,...

- other important specs are further behind on the standards track, but in good shape
  - mobile IPv6, header compression, A6 DNS support,...
  - for up-to-date status: playground.sun.com/ipng

- UMTS R5 cellular wireless standards mandate IPv6

Implementations

- most IP stack vendors have an implementation at some stage of completeness

  —some are shipping supported product today,
  e.g., 3Com, *BSD(KAME), Epilogue, Ericsson/Telebit, IBM, Hitachi, Nortel, Sun, Trumpet

  —others have beta releases now, supported products soon,
  e.g., Cisco, Compaq, HP, Linux community, Microsoft

  —others rumored to be implementing, but status unkown (to me),
  e.g., Apple, Bull, Juniper, Mentat, Novell, SGI

  (see playground.sun.com/ipng for most recent status reports)

- good attendance at frequent testing events

Deployment

- experimental infrastructure: the 6bone
  - for testing and debugging IPv6 protocols and operations
    (see www.6bone.net)

- production infrastructure in support of education and research: the 6ren
  - CAIRN, Canarie, CERNET, Chunahwa Telecom, Dante, ESnet, Internet 2, IPFNET, NTT, Renater, Singren, Sprint, SURFnet, vBNS, WIDE
    (see www.6ren.net, www.6tap.net)

- commercial infrastructure
  - a few ISPs (IIJ, NTT, SURFnet, Trumpet,…) have announced commercial IPv6 service or service trials

Deployment (cont.)

- IPv6 address allocation
  - 6bone procedure for test address space
  - regional IP address registries (APNIC, ARIN, RIPE-NCC) for production address space

- deployment advocacy (a.k.a. marketing)
  - IPv6 Forum: www.ipv6forum.com

Much Still To Do

though IPv6 today has all the functional capability of IPv4,

- implementations are not as advanced
  (e.g., with respect to performance, multicast support, compactness, instrumentation, etc.)

- deployment has only just begun

- much work to be done moving application, middleware, and management software to IPv6

- much training work to be done
  (application developers, network administrators, sales staff,…)

- many of the advanced features of IPv6 still need specification, implementation, and deployment work

IPv6 Advanced Features

- plug-and-play
  - we have most of the pieces for IP and DNS layers;
    still need work on auto-configuration of applications and services

- mobility
  - to get most efficient routing in all cases, need to deploy key distribution infrastructure

- security
  - though IPv6 enables end-to-end use of IPsec protocols (because it eliminates NATs), also dependant on key distribution infrastructure

- quality of service
  - IPv6 QoS features are same as IPv4's, but less widely implemented

Recent IPv6 "Hot Topics" in the IETF

- multihoming / address selection

- address allocation

- DNS discovery

- 3GPP usage of IPv6

- anycast addressing

- scoped address architecture

- flow-label semantics

- API issues
  (flow label, traffic class, PMTU discovery, scoping,…)

- enhanced router-to-host info

- site renumbering procedures

- temp. addresses for privacy

- inter-domain multicast routing

- address propagation and AAA issues of different access scenarios
  (always-on, dial-up, mobile,…)

- and, of course, transition / co-existence / interoperability with IPv4

Note: this indicates vitality, not incompleteness, of IPv6!

Conclusions

IPv6 is addressing the future…
- addresses for new devices, new applications, and new users
- restoring the Internet model, for performance, robustness, security, manageability, and enabling rapid innovation
- enhancing IP for next-generation applications: multicast, mobility, plug-and-play, security, and multiple qualities of service

…but is it a future we will see?
- must apply much more energy, in design, implementation, deployment, transition, training, explaining,…
- but the only way to fight entropy is to apply energy
- the past year has left me energized; you too, I hope!