IPng (IPv6)

Motivation

Currently: mainly servers, workstations, SLIP/PPP
Address space exhaustion + new uses:

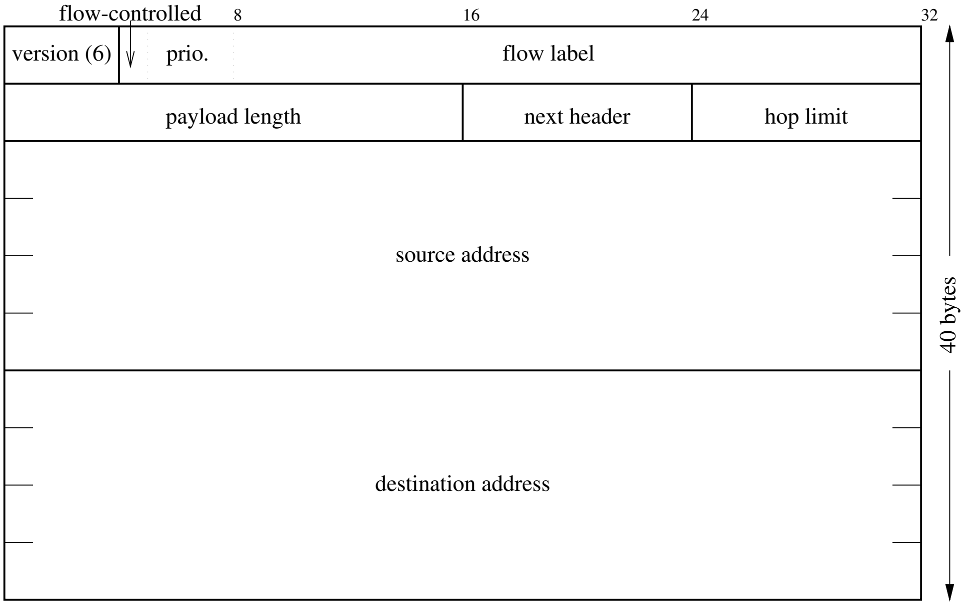
- permanently attached home computers (CATV)
- game consoles
- mobile terminals (PDAs)
- embedded controllers (light switches)

➠ new IP ➠ fix other problems
CLNP considered (variable-length addresses!), but not chosen

Address Space

- 32 bits ➠ $4 \cdot 10^9$ hosts, but can't number sequentially
- 128 bits instead of 32 bits ➠ 340,282,366,920,938,463,463,374,607,431,768,211,456 ($3 \cdot 10^{38}$) hosts or 665,570,793,348,866,943,898,599 hosts/m^2 of earth surface
- hierarchical assignment ➠ inefficiency ➠ only $8 \cdot 10^{17}$ to $2 \cdot 10^{33}$ addresses if similar to telephones, etc.
- write addresses hex, with zero suppression: 4123:::ACD9:4571:D5:F3:7

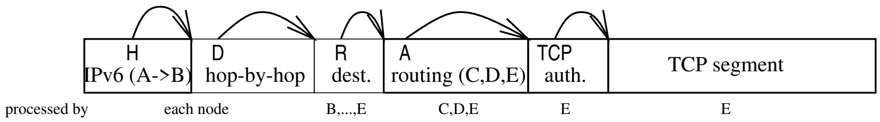
IPv6 Packet Header



IPv6 Packet Header

IPv4	IPv6
4-byte addresses	16-byte addresses
final destination	intermediate destination
precedence, TOS field	flow id, priority
header length, total length	payload length
$\leq$ 44 bytes options	"unlimited"
options	options $\in$ header extensions
router fragmentation	e-e fragmentation
header checksum	–
higher-layer protocol	next header type
TTL time-based	TTL hops only
20 bytes fixed header	40 bytes

IPv6 Packet Structure



- next header can be IPv4 "tunneling"
- header extension: hop-by-hop options (HH0), routing, fragment, destination options (DO)
- DO, HHO: type-length-value TLV options
- HHO:
  - looked at by each node, immediately after header
  - jumbo payload option (32 bits)
- routing header:
  - fixed header may not contain final address if routing header!

- mixed loose/strict source route (bitmask)
- swap destination address and next address from routing header

- fragment header: like IPv4 (32 bit identification, offset, more fragments flag)
- explicit MTU message rather than try-until-fit

IPv6 Flows

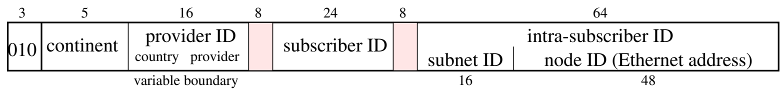
- explicit and implicit state
- router may cache based on flow identifier
- implicit state discarded after < 6 seconds
- priority ranges:
  - congestion controlled (TCP) drop priority
  - not controlled (UDP; fixed-bandwidth services)

0	uncharacterized traffic
1	filler traffic (netnews)
2	unattended data transfer (email)
4	attended bulk transfer (ftp, nfs)
6	interactive traffic (telnet, X)
7	internet control traffic (routing, network management)

Address Assignment

Administrative and topological:

0000 0000	IPv4 addresses	1/256
0000 0001	reserved	1/256
0000 001	NSAP addresses	1/128
0000 010	IPX addresses	1/128
0000 011	reserved	1/128
0000 1	reserved	3/128
0001	reserved	1/16
001	reserved	1/16
010	provider-based	1/8
011	reserved	1/8
100	geographic	1/8
…		
1111 1111	scoped multicast	1/256



Security

- authentication: insure that packet comes from right source ➠ prevent “address spoofing”
- encryption: insure privacy (DES)

Transition

- cannot have flag day
- transition period may last decade or more
- dual-stack $\rightarrow$ IPv6 can send IPv4
- IPv4 address range
- DNS servers need to understand IPv6 addresses
- avoid translation, use IPv6-in-IPv4 tunneling
- use IPv6 on same Ethernet
- end-to-end tunnel or concatenated tunnels

UDP

UDP Services

- datagram (like IP)
- protocol identifier 17
- unreliable - discarded by network or host (without notification)
- demultiplexing by process (not host)
- each datagram received by one process (“socket”) only
- no connection setup
- to answer: reverse source-destination ports
- also: audio, video, multicast

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UDP Header

0 — 16 — 32

16-bit source port number	16-bit destination port number
16-bit UDP length	16-bit UDP checksum
data (if any)	

port: “TSAP” - identifies process sending/receiving datagram

length: including header (IP length ➠ redundant)

checksum: across *pseudo-header*, UDP header, data for end-to-end reliability

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UDP Checksum Computation

0		16		32
32-bit source IP address				pseudo header
32-bit destination IP address				
zero	8-bit protocol (17)	16-bit UDP length		
16-bit source port number		16-bit destination port number		UDP header
16-bit UDP length		16-bit UDP checksum		
data (if any)				

- checksum may be turned off for better performance *at your peril*
- similar for IPng (but mandatory – why?)

UDP Port Numbers

- <512: reserved for particular services (one per host)
- $512 \dots 1023$: privileged port (Unix superuser only)
- $1023 \dots 65536$: available for applications

7	echo
9	discard
19	character generator
37	time
53	domain name service
123	Network Time Protocol (NTP)