Intro to IPv6 (nextgen)

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IPng - history

- early 90s IETF decided to accept proposals to replace IPv4, three possibilities:
  - SIP(P), Simple IP Plus (SIP + PIP = SIPP)
  - CATNIP, - based on ISO CLNP addresses
  - ISO CLNP - variable length addresses
- SIPP chosen, now IPv6 or IP next gen
- SIP advocated 64-bit addresses, IAB settled on 128 addresses for IP src/dst

reminder - scalability problems

- exhaustion of IP host addresses/IP networks. IPv6 can **address** this
  - humble apologies for inate pun
- DNS (or .com) growth. NOPE
- routing/network address scalability. CIDR addresses this, not IPv6. NOPE again.
- bottom line: if IPv6 prospers, it prospers under a CIDR administration
- put another way: **unicast allocation is important**

IPv6 header (version 3?)

0				31
version:4	priority:4	flow label:24		
payload length:16		next hdr:8	hop limit:8	
ipNG source address:128				
ipNG destination address:128				

40 byte fixed length header, no checksum, options replaced by routing extension headers

IPv6 address obviously long!

in hex notation: could be:
1234:ABCD:4321:DCBA:01FE:1212:DEAD:BEEF

8 16 bit segments in hex

note: possibility of mapping in other address spaces
(IPv4, IPX, ISO, Social Security Number)

makes DHCP server (IP/MAC binding),and DNS server
name/IP binding) a requirement

addressing, a few details

- in theory, 1500 or so addresses per square meter of earth's surface (2 **128 is big number)
- don't write leading zeros, compress with ::,
  - must write trailing zeroes
- use HEX, except allow dotted decimal IPv4 at end in one case

address high-level architecture

- FP, format prefix at FRONT is variable-length
- **allocation reserved address-space-slice**
- reserved 00000000 1/256
- unicast 001 1/8
- unique local unicast FC00/7
  - expected to be globally unique (next 40 bits)
- link-local unicast 1111 1110 10 (FE8) 1/1024
- multicast 1111 1111(FF00) 1/256

reserved addresses

- starts with 0x00, note that 0011-111X (except multicast) must have EUI-64 (MAC) bits at end
- unspecified address (all 0's):
  - 0000:0000:0000:0000:0000:0000 or ::
  - can be src during boot phase, **not destination**
- ::1 - loopback address
- ::10.0.0.1, ipv4-compatible ipv6 addr
- :: - 0 meaning "me"

local addresses

- link-local used on single link (0xfe)
  1111111010 | 0 (54 zeroes total) | if ID (64 bits)
  - auto-address configuration
  - neighbor discovery
  - no routers present
- unique local unicast (FC00::/7) - unique across subnets

anycast idea

- ipv6 addresses are anycast, unicast, multicast
- “no” broadcast - subsumed by multicast
- anycast: unicast address assigned to more than 1 interface (probably router?)
- some TBD routing technology must route packet to “nearest” interface

aggregatable global unicast addr

- in theory

				/48	/64 (hard boundaries)
FP	TLA ID	RES	NLA ID	SLA ID	interface ID
3	13	8	24	16	64 bits in field

FP = 001
TLA - top-level aggregation identifier, 8k worth,
assigned in parts to registry (RIPE,APNIC, ARIN)
NLA - next-level aggregation, to ISPs, /48 public bits
SLA - site-level aggregation, subnets within site

acc. to www.arin.net

- 2001:04AB:0000:0000:0000:0000:0000:0000/35 as a TLA/NLA allocation example

/35

FP	TLA ID	sub-TLA	Res	NLA ID	site local bits
3	13	13	6	13	80 (sla + if id)

e.g., arin allocates /35 to “big pipe inc” who allocate from NLA space to Enormous State University (ESU)

aggregation is important goal, arin wants 8k TLA routes max

whois -h rs.arin.net 2001::/21

- produces
  APNIC-001 2001:0200:0* /23
  ESNET-V6 2001:0400:0*/35
  ARIN-001 2001:0400:0*/23
  RIPE-001 2001:0600:0*/23
- **whois -h rs.arin.net ARIN-001** will produce full registration info
- ESNET-V6 is the 1st recipient of IPv6 address space from ARIN

EUI-64 in a nutshell (IPv6)

- take 48 bit MAC, divide into 2 24-bit parts
- first 24 bits to the front (of the 64 bit space),
- last 24 bits to the end
- put FFFE in the middle (now 64)
- change from left bit 7 to a 1

example:

- IPv6 address: 2610:10:20:215:250:4ff:fe76:fcf/64
- MAC address: 00:50:04:76:0f:cf
- so put 00:50:04 in the front
- 76:0f:cf in the back
- ff:fe in the middle
- change 00 to 02 for 7th bit

“transition” strategy with IPv4

- none or minimized **flag days**
- hosts have **dual-stacks**, IPv6 and IPv4
- tunnels: IPv6 internets can tunnel IPv6 packets over IPv4 networks, “short-term”
  - IPv4 | IPv6 datagram (IPv6 header + rest)
- if and when more IPv6, then IPv4 tunneled over IPv6
  - IPv6 | IPv4 datagram
- transition likely to be a very long time

some features/details

- flow-labels for QOS
- routing extension headers
- multicast addressing
- auto-configuration
- arp replaced by ICMP neighbor discovery and solitication messages using multicast (no further slides on that subject)

flow-label

- flow informally defined as “associated packets between two ES, or multicast src and all dst); .e.g, audio stream, video stream, web transaction
- at IP-level, (ip src, ip dst, priority field, flow id), flow id is src generated
- flow tuple to be used in routers for QOS scheduling

router-extension headers

- features taken OUT of ip header; .e.g., ip fragmentation
- encapsulated in additional headers that follow ip header, precede TCP/UDP level
- include: hop by hop, routing, fragment, destination options, security
- security (IPSEC): Authentication Header (AH), Encapsulating Security Payload (ESP) (encryption + optional authentication)
- recommended ordering exists for above; e.g., hop by hop first, ESP near end

fragmentation example

- IPv6 packets if too large for PATH MTU, all require router ICMP error back to sender
  - router error: path MTU here is N bytes
- sender IP must fragment

ip headers | fragment hdr | frag 1

followed by frag 2, frag 3, ... frag the last

fragment header, itself

next header	reserved	offset (13)	res	M
ip identification for ip datagram				

M = 0 on last fragment, else 1

multicast addressing

0xFF | flg(4) | scope(4) | group id (112)

flag field has 000T, where T bit if 0, means IANA assigned,
else not permanently assigned
scope bits limit multicast scope (better than current IP ttl) to
(e.g.,) link local/site local/organization local/global

routers may presumably enforce these distinctions

multicast address examples

- prefixes FF00..FF0F: followed by zero reserved
- FF01:<6 * 0000>: 0001 - node local scope
- FF02:<6 * 0000>: 0002 - link local scope
- FF01:<6 * 0000>: 0002 - node local/all IPv6 routers
- FF02:<6 * 0000>: 0002 - link local/all IPv6 routers
- range FF02:0000:0000:0000:0000:0001:FF00:0000 to
  FF02:0000:0000:0000:0000:0001:FFFF:FFFF
  - used for neighbor discovery process
- FF02:0:0:0:0:0:0: 5 and 6 used by OSPF

auto-configuration

- IEEE has extended 48-bit MAC to be 64 bits
- e.g., 48 bit MAC becomes EUI-64 by setting bit 7 to 1
  - cccccc1gcccccccccccccccc - OUI (org. unique id) in 24 bits +
  - 0xFF 0xFE (16 bits) + (insert two fixed pad bytes)
  - 24 bits of manufacturer bits
- site local address (subnet 1) hypothetical example:
- FEC0:0000:0000:0001:**020A:0AFF:FE01:0203**

stateless auto-configuration

- multicast-capable (broadcast) i/f like ethernet at boot can generate host-id portion
  - subject to duplicate address detection check
- router periodically sends router advertisement with net bytes acc. to local subnet prefix
  - flag bits indicate stateful/stateless auto-config
  - host may send router soliciation if impatient
- multicast addresses used to send these packets
- bottom-line some/all addresses can be dynamically configured

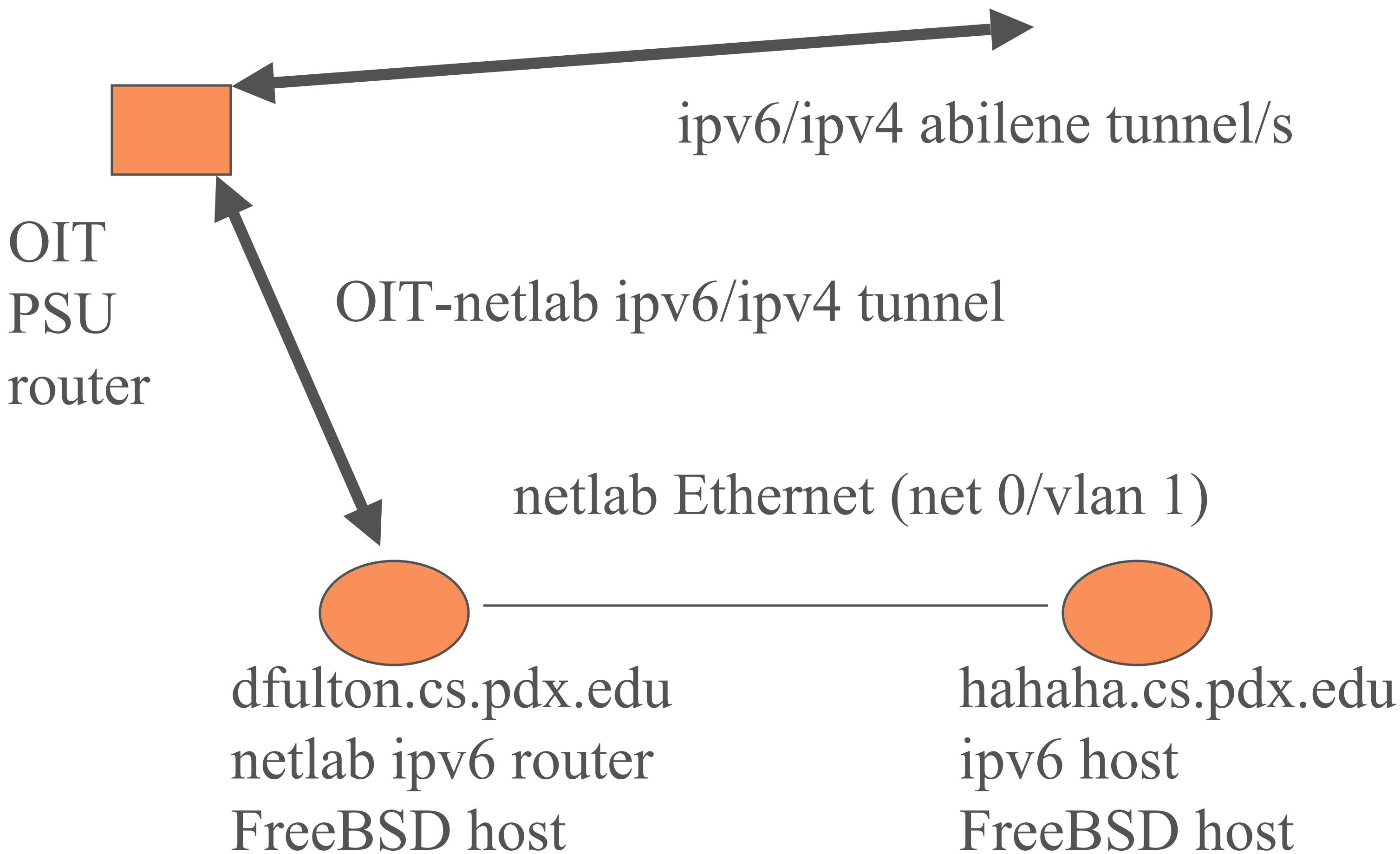
crystal-ball and final whines

- my crystal-ball is broken, unclear when IPv6 “will take over”
- not thrilled about hype believed by NAIVE folks:
  - “makes inet secure”, “mobility not possible with IPv4” “gives us Quality of Service” (sigh)
- some think didn’t go far enough for the amount of pain it will cause
- **allocation all-crucial**, and due to CIDR plus organizational experience, not IPv6
- not SIMPLE IP any more ...

IPv6 at PSU - reality check

- PSU allocation from abilene/I2: 2001:0468:1f04::/48.
- internal allocation for CECS inside of PSU: 2001:0468:1f04:0200::/56
- allocation for netlab within CECS: 2001:0468:1f04:02f0::/60
- welcome to IPv6 and CIDR ...
- remember there are 64 bits of IP

netlab IPv6 topology



dfulton setup

- there are 5 tasks
- 1. turn IPv6 “on” and enable router function
- 2. setup a gif0 tunnel to the OIT router
- 3. manually allocate an IPv6 address for the one interface used here
- 4. create a manual IPv6 default route thru the tunnel
- 5. run a router advert daemon so that auto-config will work for local subnet hosts

dfulton - router setup in /etc/rc.conf

- ipv6 on: in /etc/rc.conf
  - ipv6_enable="YES"
- enable router functionality
  - ipv6_defaultrouter="YES"
  - ipv6_gateway_enable="YES"
  - ipv6_router_enable="YES"
- rtadvert daemon
  - rtadvd_enable="YES"
  - rtadvd_interfaces="xl0"

dfulton - router setup in /etc/rc.conf

- bind ip address to xl0
  - ipv6_ifconfig_xl0_alias0="2001:468:1f04:2f0:201:2ff:fe48:9659 prefixlen 64"
- in /etc/rc.local add tunnel setup
  - ifconfig gif0 create
  - ifconfig gif0 tunnel 131.252.215.3 131.252.2.66
  - ifconfig gif0 inet6 alias 2001:468:1F04:2::2 prefixlen 64
- default route for ipv6 thru tunnel
  - route add -inet6 default -interface gif0

host setup on hahaha.cs.pdx.edu

- all we need to do is to turn ipv6 on
- however we could add commands
  - 1. rtsold <interface>
  - 2. rtsol <interface>
- for router solicitation messages
- rtsol is done at boot anyway for auto-config

ifconfig on dfulton

- # ifconfig xl0
  xl0: flags=8943<UP, BROADCAST, ...>
  ...
  inet 131.252.215.3 netmask 0xffffffe0 broadcast 131.252.215.31
  inet6 fe80::201:2ff:f348:9659%xl0 prefixlen 64 scopeid 0x
  inet6 2001:468:1f04:2f0:201:2ff:fe48:9659 prefixlen 64
  ether 00:01:02:48:96:59

ifconfig on hahaha.cs.pdx.edu

- ifconfig xl0
  inet 131.252.215.15 ...
  inet6 fe80::250:4ff:fe76:fcf%xl0 ...
  inet6 2001:486:1f04:2f0:250:4ff:fe76:fcf
  prefixlen 64 autoconf
  ether 00:50:04:76:0f:cf

note tools on freebsd

- ping6
- traceroute6
- is there a telnet6 ? (no ...)
  - very important news on the DNS front ...

DNS revisited

- **goal: support both ipv6/ipv4 lookup in the same application**
- all apps need to be rewritten, but it's not difficult
- getaddrinfo(3) replaces gethostbyname(3) and getservbyname(3) - protocol independent
- getnameinfo(3) replaces gethostbyaddr(3) and getservbyport(3)

look at handouts

- 1. Inet6 traceroute: *ipv6.traceroute6.txt*
- 2. netstat -a from a host: *ipv6.netstat.txt*
- 3.ndp -a from a host: *ipv6.ndp.txt*
- 4. look at C src example of getaddrinfo(3) *tcpclient.c*
- 5. look at C src example: *tcpserver.c*

bottom-line: so what's important?

- **cut and paste!!!**
  - all those long addresses
- auto-configuration
- tunnels (ipv4 over ipv6) "for now" (forever)
- getaddrinfo(3)