A case study of IPv6 deployment tcd.ie

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Introduction

- TCD: University $\approx$ 17000 students/staff.
- Focused on central campus.
- Maths: $\approx$ 1000 students/staff.
- Traditional Unix service (10 servers, 60 xterms).
- Deployment 'plan' for IPv6.

Example IPv6 Addresses

- 2001:0770:0010:0300:0000:0000:86e2:510b
- 2001:770:10:300:0:0:86e2:510b
- 2001:770:10:300::86e2:510b
- 2001:770:10:300::134.226.81.11

Special Addresses

::	Unspec
::1	localhost
fe80:: block	link-local
fec0:: block	site-local
ff00:: block	multicast

Stage 1: Getting Started

```
% ifconfig -a
lo0: flags=8049<UP,LOOPBACK,RUNNING,MULTICAST> mtu 16384
        inet6 ::1 prefixlen 128
        inet6 fe80::1%lo0 prefixlen 64 scopeid 0x1
        inet 127.0.0.1 netmask 0xff000000
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        inet6 fe80::203:93ff:fe46:17a6%en0 prefixlen 64 scopeid 0x4
        inet 10.0.0.1 netmask 0xff000000 broadcast 10.255.255.255
        ether 00:03:93:46:17:a6
```

Pinging & ssh

```
% ping6 ::1
PING6(56=40+8+8 bytes) ::1 --> ::1
16 bytes from ::1, icmp_seq=0 hlim=64 time=0.392 ms
% ping6 -I en0 fe80::230:65ff:fe03:d972
16 bytes from fe80::230:65ff:fe03:d972%en0, icmp_seq=0 hlim=64 time=1.373 ms
% ping6 -I en0 ff02::1
PING ff02::1(ff02::1) from fe80::2b0:d0ff:fed7:741d en0: 56 data bytes
64 bytes from ::1: icmp_seq=1 ttl=64 time=0.062 ms
64 bytes from fe80::2b0:d0ff:fe05:fc06: icmp_seq=1 ttl=64 time=0.194 ms (DUP!)
64 bytes from fe80::206:5bff:fe68:249b: icmp_seq=1 ttl=64 time=0.224 ms (DUP!)
64 bytes from fe80::202:b3ff:fe65:604b: icmp_seq=1 ttl=64 time=0.256 ms (DUP!)
64 bytes from fe80::2b0:d0ff:fef4:c6c5: icmp_seq=1 ttl=64 time=0.334 ms (DUP!)
64 bytes from fe80::203:93ff:fe46:17a6: icmp_seq=1 ttl=64 time=0.384 ms (DUP!)
...
% ssh fe80::2b0:d0ff:fef4:c6c5%en1
dwmalone@fe80::2b0:d0ff:fef4:c6c5%en1's password:
```

As good as your Ethernet multicast.

Stage 2: IPv6 connectivity

- Use tunnel (Protocol 41).
- 2001:618:400:e::/64 address space from BT.
- Use ip6fw for filtering.

```
% ifconfig gif0 create
% ifconfig gif0 tunnel 134.226.10.51 193.113.58.80
% ifconfig gif0 inet6 2001:618:400::1:DC4:1467 2001:618:400::1:DC4:1466 prefixlen 128
% route add -inet6 default 2001:618:400::1:DC4:1466
% ifconfig fxp0 inet6 2001:618:400:e::1 prefixle 64
% ip6fw add 100 deny  all from 2001:618:400:e::/64 to any in via gif0
% ip6fw add 200 allow all from 2001:618:400:e::/64 to any in via fxp0
% ip6fw add 300 allow all from fe80::/10 to any in via fxp0
% ip6fw add 400 allow all from :: to ff02::/16 in via fxp0
% ip6fw add 500 deny  all from any to any in via fxp0
% sysctl net.inet6.ip6.forwarding=1
```

Rtadvd

- Configure prefix 2001:618:400:e::
- Node gets 2001:618:400:e:2a0:c9ff:feb1:34e7
- Use `rtadvd fxp0` on FreeBSD.
- Advertises prefix, router, lifetimes, MTU...
- Can cause problems: Rapid prefix changes, Misplugged routers...

Problems with routing

- Scenic routing between {cs,maths}.tcd.ie.
- /48 from BT. Tunnel: BT to CS, CS to Maths.
- Addressing 'plan'
  2001:618:409:100:: — ISS,
  2001:618:409:200:: — CS,
  2001:618:409:300:: — maths,
  2001:618:409:400:: — reserved.
- Renumbered when allocated 2001:770:10::/48 by HEAnet.

Stage 3: Services

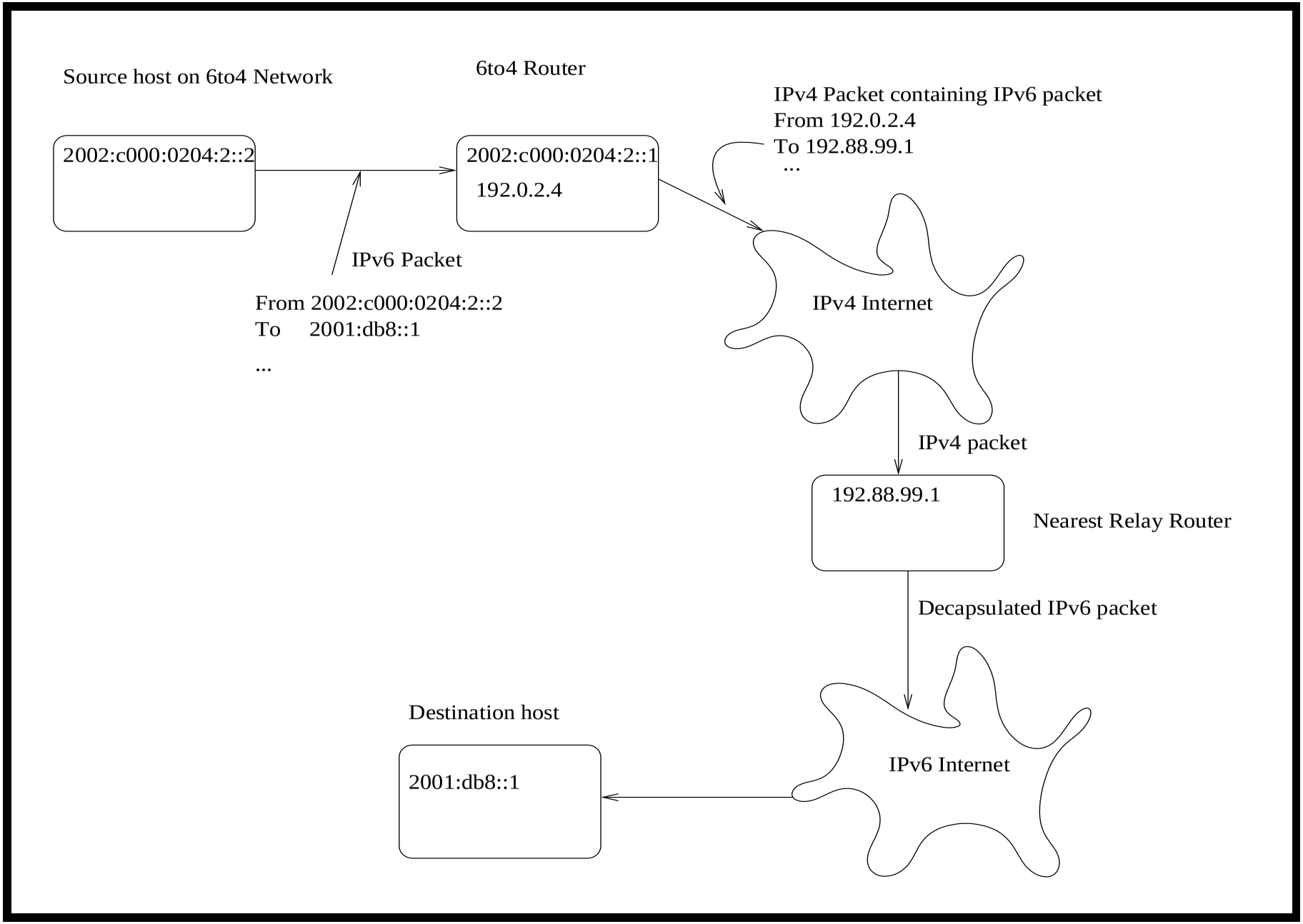
- To be useful need DNS info:
- A: salmon →134.226.81.11.
- PTR: 11.81.226.134.in-addr.arpa → salmon
- AAAA: salmon.ipv6 → 2001:770:10:300::...
- PTR: ...0.7.7.0.1.0.0.2.ip6.arpa → salmon.ip6
- New reverse zone delegated from upstream.

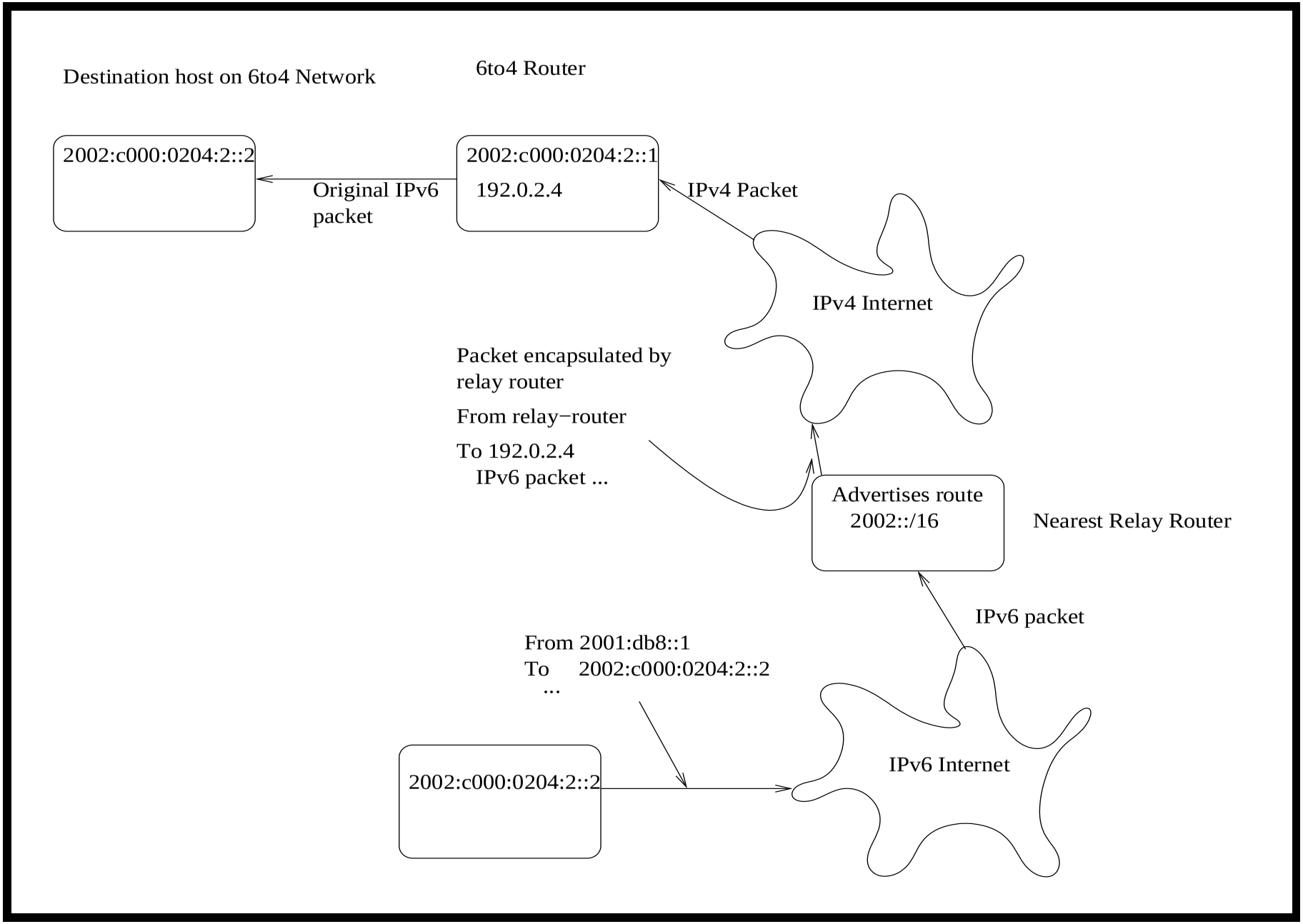
Testing

- After updating known hosts, seems good.
- Further tests to before AAAA for normal names.
- IPv6 at home. Search ipv6.maths.tcd.ie first.
- All still good, add AAAA for normal names.

Connecting at home

- 6to4 — very easy, easy config.
- www.xxx.yyy.zzz → 2002:WWXX:YYZZ::
- Eircom, Esat and HEAnet offer relays.
- Tunnels now available to those with fixed IPv4.


Source host on 6to4 Network
6to4 Router
IPv4 Packet containing IPv6 packet
From 192.0.2.4
To 192.88.99.1
...
2002:c000:0204:2::2
2002:c000:0204:2::1
192.0.2.4
IPv6 Packet
From 2002:c000:0204:2::2
To 2001:db8::1
...
IPv4 Internet
IPv4 packet
192.88.99.1
Nearest Relay Router
Decapsulated IPv6 packet
Destination host
2001:db8::1
IPv6 Internet


Destination host on 6to4 Network
6to4 Router
2002:c000:0204:2::2
2002:c000:0204:2::1
192.0.2.4
Original IPv6
packet
IPv4 Packet
IPv4 Internet
Packet encapsulated by
relay router
From relay−router
To 192.0.2.4
IPv6 packet ...
Advertises route
2002::/16
Nearest Relay Router
IPv6 packet
From 2001:db8::1
To 2002:c000:0204:2::2
...
2002:c000:0204:2::2
IPv6 Internet

Web Server

Upgrade to Apache2

- s/Port 80/Listen 80/
- Add IPv6 addrs to `.htaccess` files.
- Update log processing scripts.
- PHP problems? Run as CGI.
- Linux sendfile & checksum offloading.

DNS & Bind 9 (or 8.4)

Having AAAA and doing DNS *over* v6 different.

named.conf:

```
+       listen-on { any; };
+       listen-on-v6 { any; };
        query-source address * port 53;
+       query-source-v6 address * port 53;
-       acl tcd { 134.226.0.0/16; }
+       acl tcd { 134.226.0.0/16; 2001:770:10::/48; }
```

zone file:

```
 ; Master nameserver for maths.tcd.ie.
 ns             IN      A       134.226.81.11
+               IN      AAAA    2001:770:10:300::86e2:510b
```

Glue in .tcd.ie and .ie zone. Autoconf?

Mail

IPv6 sendmail, postfix (patch), qmail (patch), exim.

We use MMDF — challenge by Dave Wilson.

- Receive mail from network.
- Look up addresses for MX.
- Send mail to network.

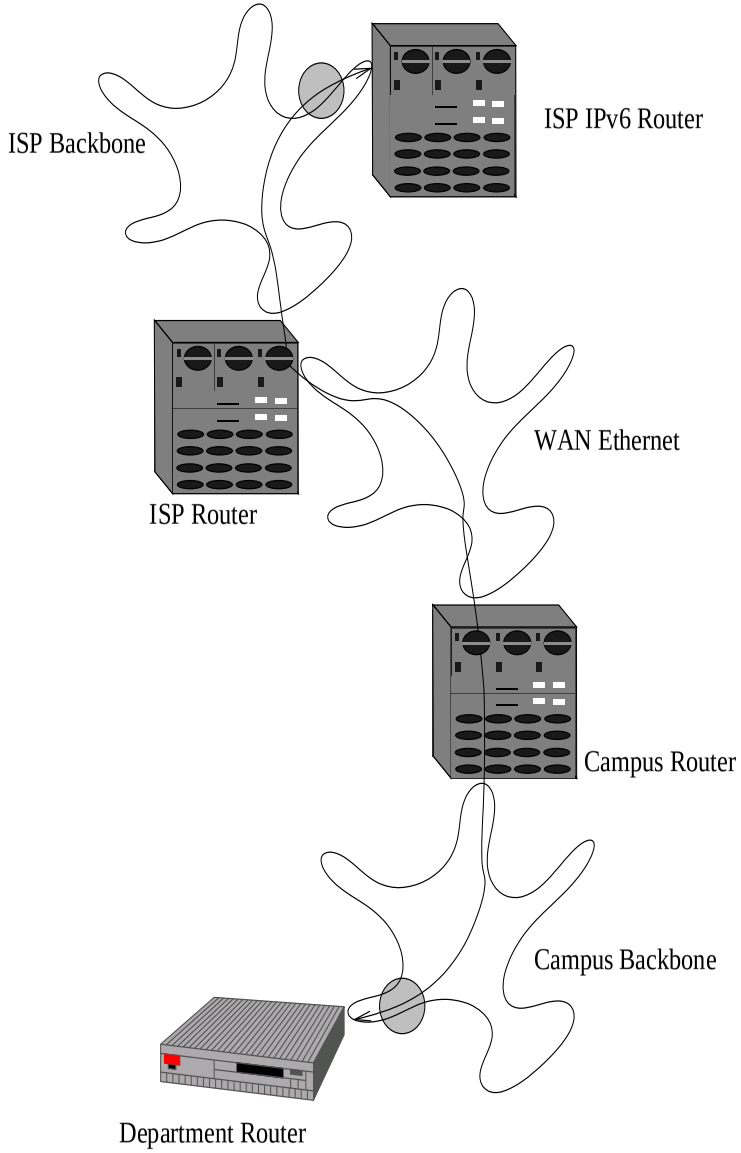
Converting Apps

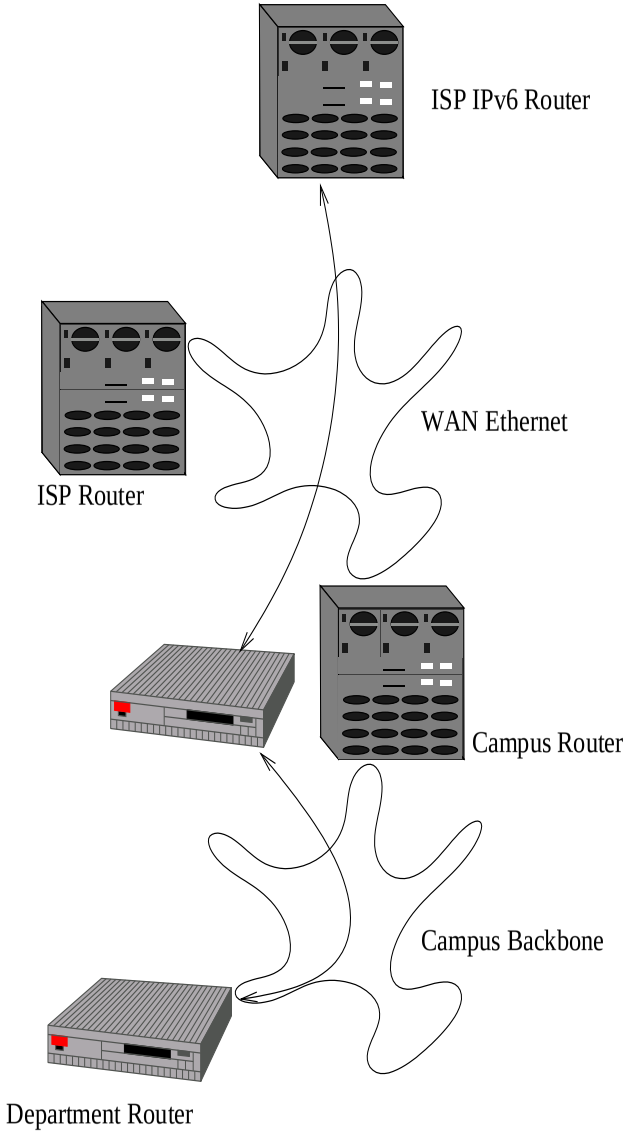
- Sockets pretty agnostic: `s/AF_INET/AF_INET6/`
- Need to look up A and AAAA records.
- New functions getaddrinfo and getnameinfo.

```
struct addrinfo hints, *res, *res0;
int s;
memset(&hints, 0, sizeof(hints));
hints.ai_family = PF_UNSPEC;
hints.ai_socktype = SOCK_STREAM;
getaddrinfo("www.kame.net", "http", &hints, &res0);
for (res = res0; res; res = res->ai_next) {
        s = socket(res->ai_family, res->ai_socktype,
            res->ai_protocol);
        if (connect(s, res->ai_addr, res->ai_addrlen) < 0)
                continue;
        break;
}
freeaddrinfo(res0);
```

Wait and see

- HTTP ≈500/d (max 96K!),
  SMTP ≈50/d each way.
- Use multicast to monitor population.
- Increasing numbers: OS X, Linux, *BSD.
- Link moved to native Ethernet.
- Protocol redundancy during SQLslammer!


ISP Backbone
ISP IPv6 Router
WAN Ethernet
ISP Router
Campus Router
Campus Backbone
Department Router


ISP IPv6 Router
WAN Ethernet
ISP Router
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Other services

- NNTP: innd+patch, Diablo-CVS.
- FTP: wu-ftpd+patch, tweaks for reverse DNS.
- ident, lpd, courier-imap.
- cvsup: netcat fudge.
- NTP: 4.1.80 problems with fall-back.
- WiFi: router + switch + APs.
  Need short lifetimes.

Stage 4: Future

- Working on college host.db, DNS, HTTP.
- Use FreeBSD/Linux vifs to connect all vlans?
- Need to IPv6 finger and *web proxy*.
- Bad doubleclick!
- Internal services: NFS, X11, phone, samba, snmp, diskless xterms...

Summary

1. link-local setup
2. connectivity, filtering, route advertisment.
3. test DNS, services, real DNS.