Distributing Requests for DNS Service

Joe Abley, ISC

BSDCAN, Ottawa, 2004

ISC

- Used to be Internet Software Consortium
- Now Internet Systems Consortium (since January 2004), US 501(c)3 non-profit
- We maintain and develop BIND
- We operate the F root nameserver, and provide slave service for 30-40 ccTLD zones

ISC

- We will sell you a support contract for BIND, if you like
  - (since there are government people here)
  - (stop throwing things)

Concepts

- DNS
  - authoritative nameservers, recursive nameservers
- IP Routing
  - unicast forwarding, anycast routing
  - OSPF

Background

Starting Point

- Discrete, single-host authoritative nameservers
    - several (two or more)
    - geographically dispersed
- Discrete, single-host recursive resolvers
    - several (two or more)

What is Broken?

- Single points of failure in service delivery (single host providing service)
- Maintenance windows (we can’t take the host down for maintenance without breaking the service)
- Scaling for request loads (we need to take the server down for upgrades, and that breaks the service)

How Broken is it?

- Authoritative DNS servers: not very broken
  - multiple, independent servers in an NS set
  - resolvers good at retrying, then caching
  - depends on how important the zone is
- However, even for zones of only moderate importance, adding redundancy cheaply can make sysadmins' lives easier

How Broken is it?

- Recursive Resolvers: quite broken
  - clients are typically stupid; they might have multiple configured nameservers, but they're not very good at coping when one disappears
  - when the DNS doesn't work, nothing works, makes the helpdesk phone ring
    - My Internet Is Down

Some Solutions

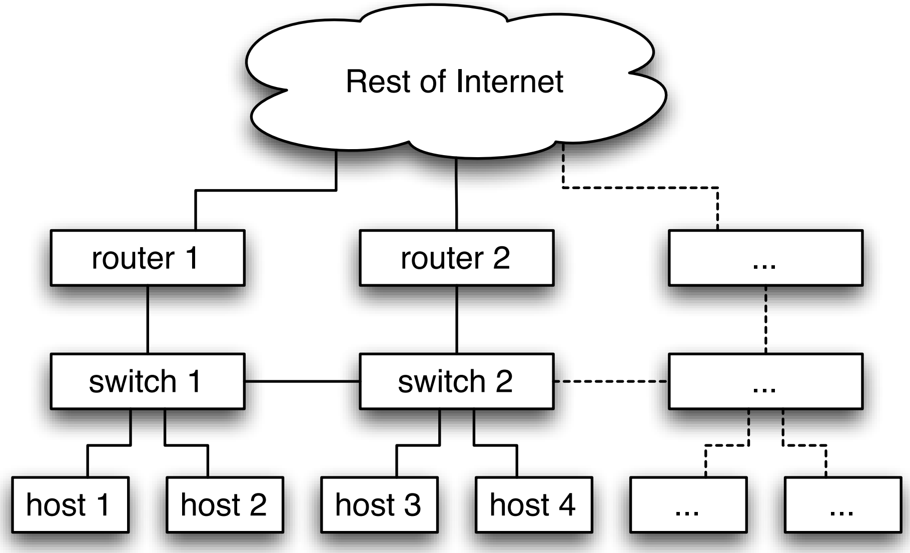
- Commercial O/S clusters (Sun, HP, etc)
- Commercial load-balancers (Foundry, Arrowpoint/Cisco, Cisco, Alteon/Nortel)
- CARP (don’t know, haven’t tried it yet)
- Anycast with equal-cost paths and flow hashing (which is what we do)

Common Requirement

- The service being distributed has its own IP address
  - sometimes called a "VIP" by the commercial load-balancing people
  - useful for other reasons than just load balancing (e.g. moving services between hosts, sites)

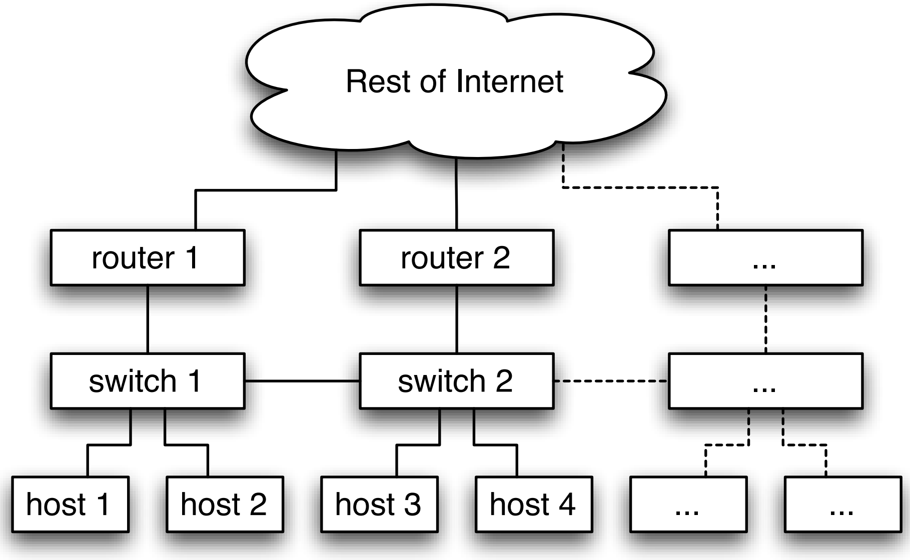
General Approach

IP Addressing



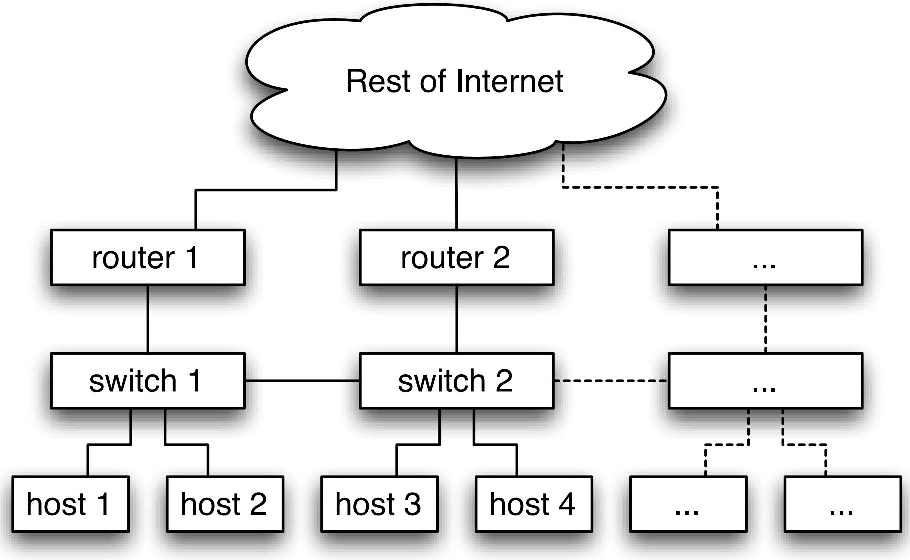
- Globally-unique, unicast addresses on each host
- Service addresses configured on loopbacks on hosts (anycast)

Connectivity



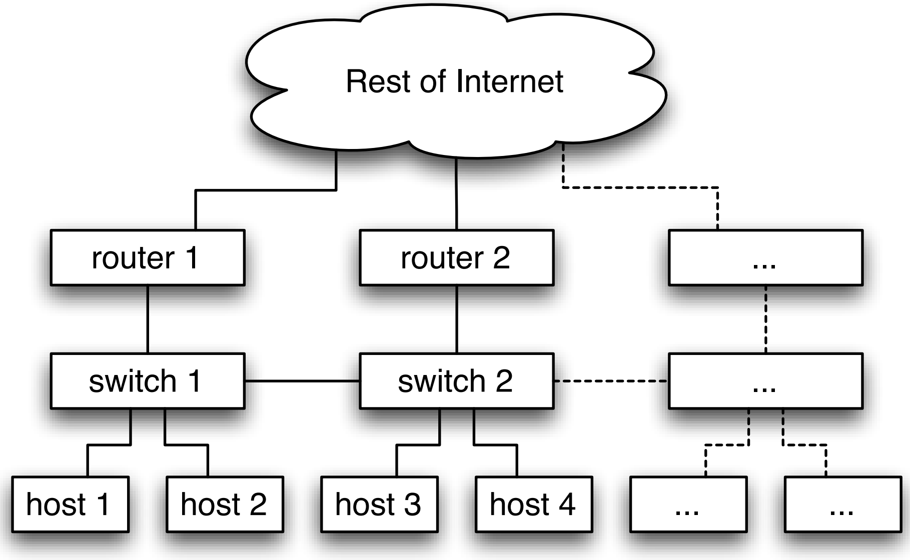
- Routers and hosts communicate within a common subnet (e.g. a VLAN plumbed through some switches)

Host Configuration



- Hosts are autonomous
- Hosts respond to requests on the service address, and are managed via their unique, unicast addresses

Routing

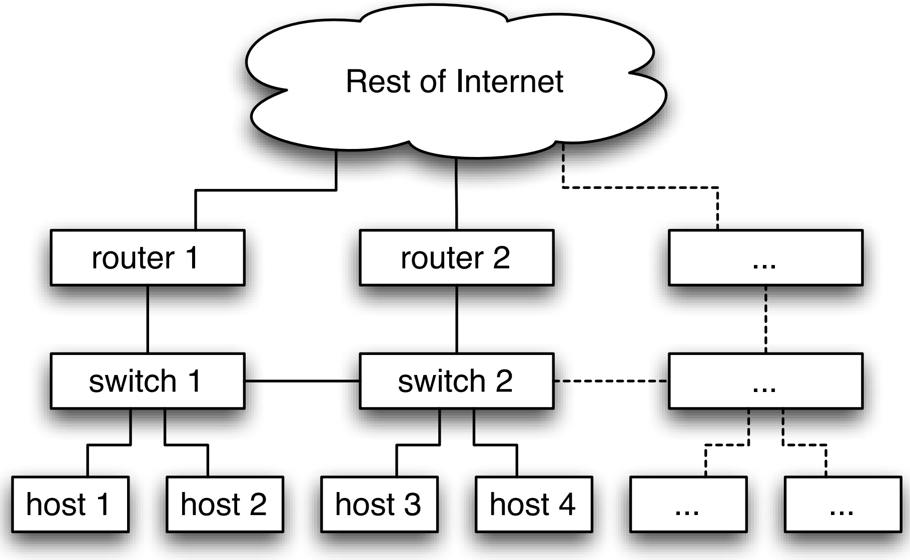


- Routers and hosts speak OSPF

- Routers originate a default route for the hosts to use

- Hosts originate a host route (an IPv4 /32, or an IPv6 /128) for the service address

Routing



- Request from Internet routed to one of the hosts by the routers
- Response generated by host sent out towards one of the routers by the host
- Life is Good
- Smile Happily

Niggly Details

Routers

- The routers need equal-cost multipath (ECMP) support
    - multiple candidate routes to the same destination
    - multiple routes used (installed in the FIB)
    - most commercial routers can do this; most host operating systems can’t

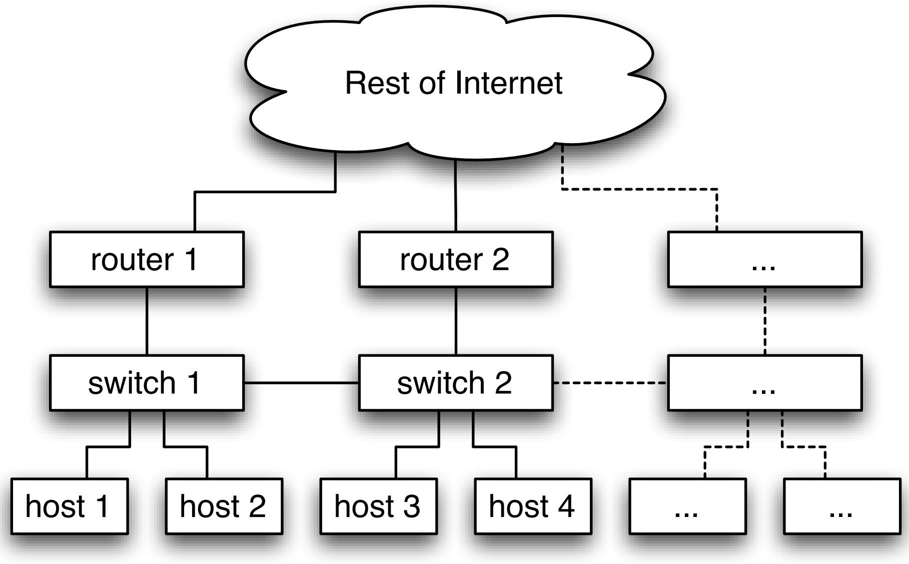
Stateless Transactions

- For DNS queries carried over UDP, with no fragmentation, a transaction consists of a single packet request and a single packet response
  - no additional requirements on the routers
  - easy

Stateful Transactions

- Transactions carried over TCP involve multi-packet requests, and state is kept on the hosts
- All packets associated with a single transaction need to be routed to the same host, or nothing will work

Stateful Transactions

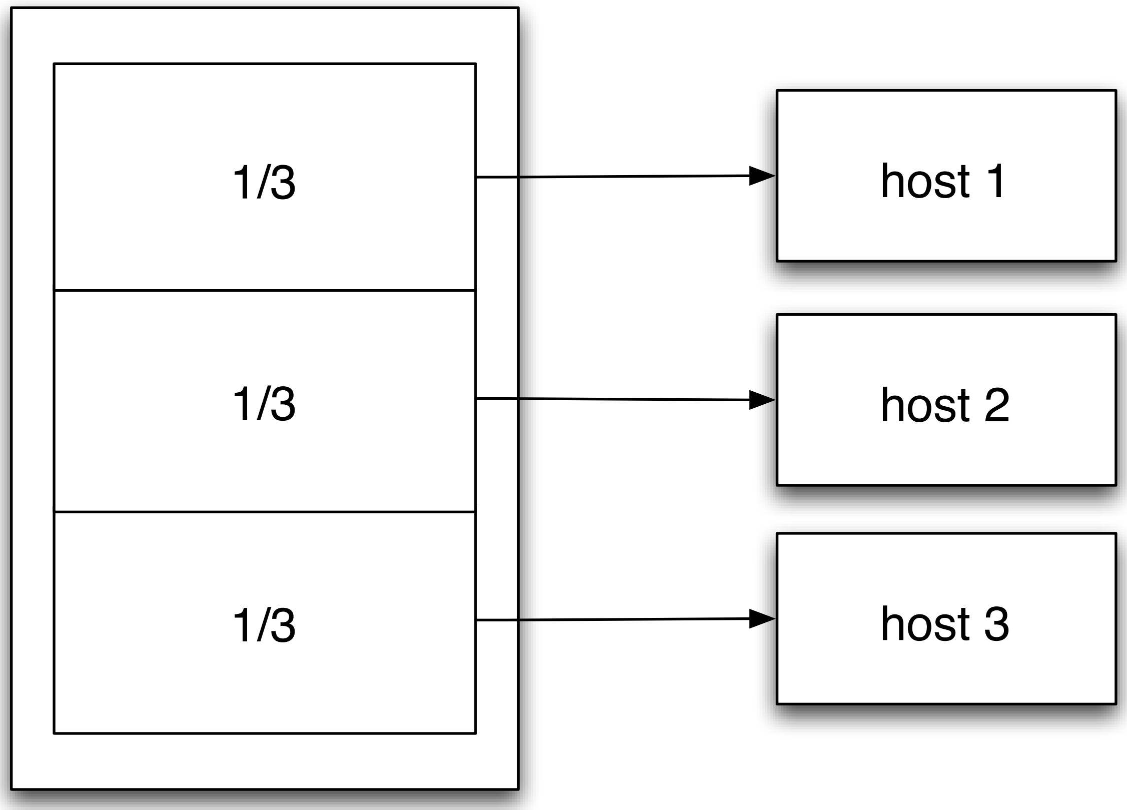


Flow Hashing

- Routers are required to make their ECMP route selection such that packets associated with a single transaction are routed to a single host
- cisco and Juniper routers can do this; the route selection can be done according to a hash of (source addr, source port, dest addr, dest port) which provides the flow grouping we need

Hash Space

(source addr, source port,
dest addr, dest port)



1/3

1/3

1/3

host 1

host 2

host 3

Flow Hashing

- On cisco routers this ECMP selection algorithm is turned on with Cisco Express Forwarding (CEF)
- On Juniper routers, the magic phrase is “load-balance per-packet”

Flow Hashing

- The hash table is per-router, so we also need to make sure that packets associated with a single flow are always routed inbound from the Internet through the same router
  - turn on CEF everywhere
  - avoid ECMP routes
  - use routing protocols that don’t support ECMP (like BGP)

Example Configuration

```
ip cef
!
interface FastEthernet1/0
 description interface facing the hosts
 ip address 192.168.1.1 255.255.255.0
!
router ospf 1
 network 192.168.1.0 0.0.0.255 area 0
 default-information originate always
```

Host Requirements

- No need for ECMP support
- Availability of service signalled to routers using OSPF link-state advertisements
- Zebra’s ospfd does everything that you need

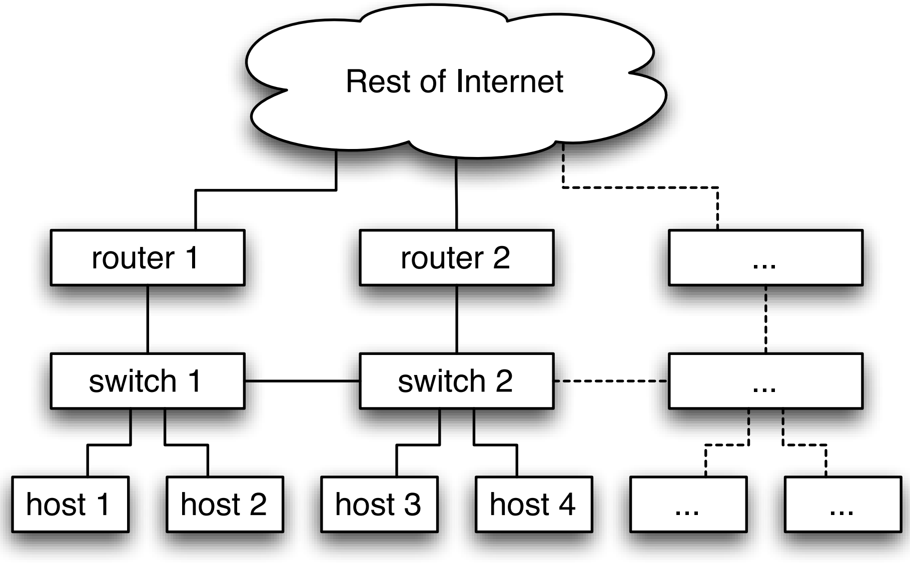
Example Configuration

```
interface lo1
 ip address 192.5.5.241 255.255.255.255
!
interface fxp0
 ip address 192.168.1.6 255.255.255.0
!
router ospf 1
 network 192.5.5.241 0.0.0.0 area 0
 network 192.168.1.0 0.0.0.255 area 0
 passive-interface lo0
```

BIND Bits

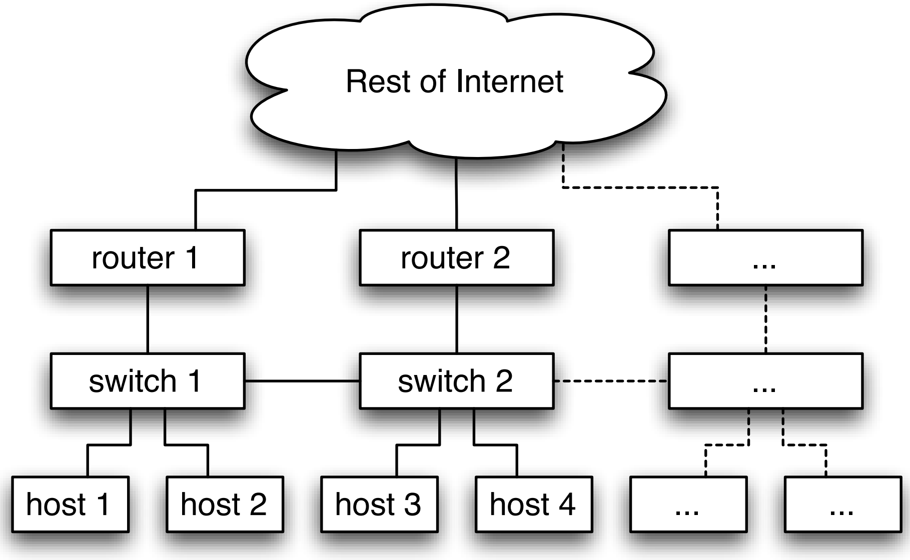
- bind() to service address for receiving requests
- bind() to the host's unique unicast address for everything else (recursive lookups, zone transfers, etc)

Zone Transfers



- Slave servers do zone transfers
- Zone transfers authenticated by source address are problematic if the source is the anycast service address
- Only 1/N requests will succeed

Zone Transfers



- Workaround: all hosts attempt zone transfers from the master server and from each other

- BIND falls back to unbound socket after failing with configured transfer-source

- Use TSIG

Reliability

- If a nameserver goes bad, we don’t want requests routed to it
    - named dumps core if internal assertions fail
    - simple wrapper can be used to raise/lower the service loopback address when named exits, withdrawing and announcing the service as appropriate

Service Monitoring

- Need to check individual hosts, since checking the service address from one test client only really checks one host
    - that doesn't reveal whether the routing system is working, though, or whether there are bad firewall rules in place

Troubleshooting

- HOSTNAME.BIND CH TXT
  - BIND 8, BIND 9 from 9.3
  - Future EDNS extension, maybe, one day
- Keep reminding people that different clients will hit different servers, and that the customer on the phone is not necessarily lying

Limitations

General

- Commercial load balancers usually offer a bucket load of load-sharing schemes (least-recently-used, least-loaded-server, etc)
- Doing rigourous, real-life tests of the service is problematic due to anycast
  - common to most load-sharing solutions
- It is not possible, in general, to determine the precise host that answered a request from a particular client

Other Protocols

- DNS
  - most traffic is stateless
  - transactions are short-lived
- Other applications
  - different

Wrapping Up

Related Exercises

- Distribution of recursive resolvers through a network
  - use a local server, fall back to a remote one
  - avoids load-sharing considerations, since there are no ECMP routes

More Information

- http://www.isc.org/pubs/tn/isc-tn-2004-1.html
- http://www.isc.org/pubs/tn/isc-tn-2004-1.txt
- http://www.isc.org/pubs/pres/BSDCan/2004/usenix-isc-dns-dist.pdf
- http://www.isc.org/pubs/pres/BSDCan/2004/bsdcan-isc-dns-dist.pdf
- jabley@isc.org