Three Practical Ways to Improve Your Network

Kevin Miller
Carnegie Mellon University
kcm@cmu.edu
Overview

- Eliminate users
- Perfectly secure operating systems
- Infinitely reliable hardware

Emphasis on the *practical*
Overview

- IP Anycast
  - Deployment Example
- Source Address Verification
  - Unicast Reverse Path Forwarding
- uRPF for Host Filtering
  - Fast filtering by IP source address
IP Anycast

• Current “Anycast” is “shared unicast”
  – Just a method of configuring routers, hosts in slightly different way
  – Not multicast, don’t be worried

• Assign IP address to multiple hosts
  – Still need a unique management address

• Announce routes to anycast IPs from multiple locations
IP Anycast - Configuring

• Configure servers to respond on anycast addresses
  – Often, no additional work required

• Configure clients to use anycast address instead of unique address
  – Recursive DNS: anycast IP configured as resolver
  – Other protocols: update DNS A record
Anycast in Action

Anycast address 128.2.1.10 configured on 3 servers
Anycast in Action

Routers D, E, F have route to 128.2.1.10 via unique address of server
Anycast in Action

Router A selects one best path (or equal cost multi path to D, E, F)
Anycast in Action

Client 1 sends a packet, dest address 128.2.1.10
Anycast in Action

Server responds; source address is 128.2.1.10
Anycast in Action

Subsequent packets can arrive at different servers

Client 1 → B → A

A → D: 128.2.10.50
128.2.1.10(A)

A → E:
- 128.2.64.2
- 128.2.1.10(A)

A → F:
- 128.2.32.37
- 128.2.1.10(A)

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Caching DNS

• Problems
  – Network appears slow on most OSs when primary DNS server is unreachable
  – Difficult to relocate caching DNS servers

• Anycast as the solution
  – Client transparency (easy to move)
  – Service reliability
DNS Clients are Forgetful

OS Resolvers that don’t remember a dead DNS server:

- Cisco IOS 12.1
- FreeBSD 5.1
- Linux 2.4.20
- Mac OS X 10.2.6
- OpenBSD 3.3
- Solaris 8
- Windows 2000 – SP3

Those that do:

- Windows XP
DNS Timeouts Can Be Long

DNS Query Timeout of Several Operating Systems

Seconds

- Cisco IOS
- FreeBSD
- Linux
- Mac OS X
- OpenBSD
- Solaris
- Windows 2000
- Windows XP

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## Compounding the Delay

<table>
<thead>
<tr>
<th>Start</th>
<th>Query</th>
<th>Type</th>
<th>Server</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>0s</td>
<td><a href="http://www.usenix.org">www.usenix.org</a>.</td>
<td>AAAA</td>
<td>ns1</td>
<td>Timeout</td>
</tr>
<tr>
<td>1s</td>
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<td>AAAA</td>
<td>ns2</td>
<td>NXDOMAIN</td>
</tr>
<tr>
<td>1s</td>
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<td><a href="http://www.usenix.org.a.example.com">www.usenix.org.a.example.com</a>.</td>
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<td>Timeout</td>
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<tr>
<td>4s</td>
<td><a href="http://www.usenix.org">www.usenix.org</a>.</td>
<td>A</td>
<td>ns2</td>
<td>NOERROR</td>
</tr>
</tbody>
</table>
Caching DNS Deployment

- Decided to use anycast for caching DNS
- Select anycast IP addresses
  - 128.2.1.10, 128.2.1.11 (CMU: 128.2/16)
- Assign addresses to clients
  - DHCP, PPP, internal documentation, smoke signals
Caching DNS Deployment

- Configure anycast addresses on servers
- Restrict servers to respond only on anycast addresses
  - Prevent dependencies upon unique addresses
- Ensure queries originate from unique address

BIND 9 Changes

```
options {
    listen-on { 128.2.1.10; 128.2.1.11; };
    query-source address 128.2.4.21;
};
```
• Configure routing daemon on DNS servers
  – Join our OSPF routing cloud
  – Minimizes outage time when server is down

<table>
<thead>
<tr>
<th>Typical Routing Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;show ip route 128.2.1.10</td>
</tr>
<tr>
<td>Routing entry for 128.2.1.10/32</td>
</tr>
<tr>
<td>Routing Descriptor Blocks:</td>
</tr>
<tr>
<td>* 128.2.255.24, from 128.2.4.242, 1d13h ago</td>
</tr>
<tr>
<td>128.2.255.10, from 128.2.4.238, 1d13h ago</td>
</tr>
<tr>
<td>128.2.255.35, from 128.2.4.228, 1d13h ago</td>
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</table>
Caching DNS Deployment

- Some clients directed locally, while others load balanced
- If server fails, reroute in < 10 seconds
Other Potential Uses

- Authoritative DNS (RFC3258)
  - Root servers F, I, K
  - .ORG TLD
- Multicast RP (RFC3446)
- 6to4 Tunneling Routers (RFC3068)
- Syslog, RADIUS, Kerberos
- Single packet request-response UDP protocols are “easy”
- Many services are using anycast; changes network troubleshooting steps
Source Address Verification

- Validate the IP source address of packets entering a router
  - Drop packets with unexpected addresses
- Improve network security
  - Popular DoS vector: spoofing source addresses (Teardrop, Smurf among first)
  - Harder to track back spoofed sources
Methods of SAV

- BCP38 recommends network operators deploy ingress filters restricting traffic
  - Acceptable solution, but difficult to implement in the network core
  - Requires operator maintenance and upkeep
  - Stale access lists become a problem

- Research into better ways
  - SAVE Protocol: Additional inter-router communication of allowed ranges
Unicast Reverse Path Forwarding

- Unicast Reverse Path Forwarding
  - Uses unicast forwarding table as policy source; filters adjust dynamically
  - Easy to implement at the edge
  - ‘Loose’ mode acceptable in the core

- Accept packet from interface only if forwarding table entry for source IP address matches ingress interface
uRPF in Action

No source address verification on router A; invalid source addresses
**uRPF in Action**

**Strict Mode uRPF Enabled**

**10.0.18.3 from wrong interface**

**"A" Routing Table**

<table>
<thead>
<tr>
<th>Destination</th>
<th>Next Hop</th>
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</thead>
<tbody>
<tr>
<td>10.0.1.0/24</td>
<td>Int. 1</td>
</tr>
<tr>
<td>10.0.18.0/24</td>
<td>Int. 2</td>
</tr>
</tbody>
</table>

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uRPF in Action

Loose Mode uRPF Enabled

10.0.18.3 passing, since it exists in the routing table
uRPF in Action

Loose Mode uRPF Enabled

10.12.0.3 still not in routing table; dropped
Host Filtering

• Problem:
  – Want to be able to block traffic from certain source addresses quickly
    • Access restrictions (worm-infected hosts)
    • Inbound or outbound traffic flooding
  – Implemented using scripts that talk to routers; hope the router is talking ‘correctly’
    • Requires passwords; tedious to maintain
    • Doesn’t take too long, but we can do better...
Host Filtering

• Note:
  – uRPF strict mode drops packets with source interface other than next-hop interface of FIB entry for source IP
  – FIB lookups are done using longest prefix matching
  – uRPF strict mode should be in use on every edge interface!
Host Filtering with uRPF

- To filter traffic from an IP, create a FIB entry with /32 prefix for IP (“host route”) – with next-hop of anything other than normal ingress interface
- FIB entries can be easily created by propagating host route into IGP
Active Filtering

Infected host spewing traffic

Strict Mode uRPF

Sinkhole

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10.0.1.5

10.0.1.8

10.0.1.20
Active Filtering

Sinkhole announces host route for infected host
Active Filtering

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Traffic to 10.0.1.8 discarded at sinkhole router
Active Filtering

Because of uRPF, traffic from host is discarded (next hop interface towards sinkhole)

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Sinkhole

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10.0.1.8
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Active Filtering

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Host fixed; administrator configures sinkhole to drop route
### Three Practical Ideas

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<td>Using IP anycast for caching DNS can improve the reliability of recursive DNS service and ease server management tasks.</td>
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<td>Unicast Reverse Path Forwarding provides an easy, self-maintaining mechanism for source address verification. Enabling uRPF on edge interfaces should become standard operating procedure.</td>
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<td>uRPF can be effectively leveraged to quickly apply source address filters. Fast filtering in this manner reduces the response time to network exploits.</td>
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Questions?

- Presentation resources: http://www.net.cmu.edu/pres/lisa03
- Kevin Miller: kcm@cmu.edu