Response Rate Limiting with BIND

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ISC

About the Presenter

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- Configuration Inspector, Consultant
- BIND & ISC DHCP Trainer
- 20+ years of DNS, DHCP and sysadmin experience

Agenda

- ISC at a Glance
- State of the Net - DDoS
- What is a DNS-based DDoS Attack?
- How can Response Rate Limiting (RRL) help?
- Enabling RRL
- RRL Configuration Options
- RRL Classifier
- Q&A

ISC at a Glance

Public Benefit

- F-Root: Critical Internet Infrastructure
- Open Source Software; BIND & DHCP

Commercial Services

- Subscription Services
  - BIND and DHCP
- Secondary Name Service
- Training

State of the Net - Cyber Attacks

- Cyber attacks against US businesses *increased 42%* compared to the previous year Symantec.

- Over 50% of the significant online operations experience five or more 2-6 hour DDoS attacks per month FORRESTER®

- DDoS attacks increased 20% in Q2, 2013, and have risen across the board in size, strength, and duration PROLEXIC DDoS Attacks End Here.

Distributed Denial of Service Attack

- DDoS attacks are used by malicious parties to force a computer resource—a website, network, or application—to stop responding to legitimate users.

- **Motives**
  - Ideology/Vendetta
  - Politics
  - Competition
  - Cloaking Criminal Activity
  - Extortion
  - Because we can…

- **Examples**
  - Smurf Attack
  - (S)SYN flood
  - Reflected DoS

Reflected DoS Attacks

- rDoS involves sending forged requests of some type to a very large number of computers that will reply to the requests

  Two steps are taken to conduct such an attack:

  1. Attacker modifies IP packet data through Internet Protocol address spoofing

  2. Attacker searches for responses that are several times bigger than the request

Normal Traffic

rDoS Attack


5.6.7.8
Source IP Address:
~~5.6.7.8~~
1.2.3.4
Internet
Responds to 1.2.3.4
1.2.3.4

DDoS and DNS

- **DNS is easily used for DDoS:**
  - DNS lacks any source validation features
  - Most ISPs don't check the source address of packets they send
  - Small DNS queries can generate large responses
    - DNS Amplification Attacks

Accidental(?) DNS Attacks

Poor Network Hygiene

- Non-caching name servers
- Too frequent flushing
- Open recursive servers (some 33 Million, in fact!)

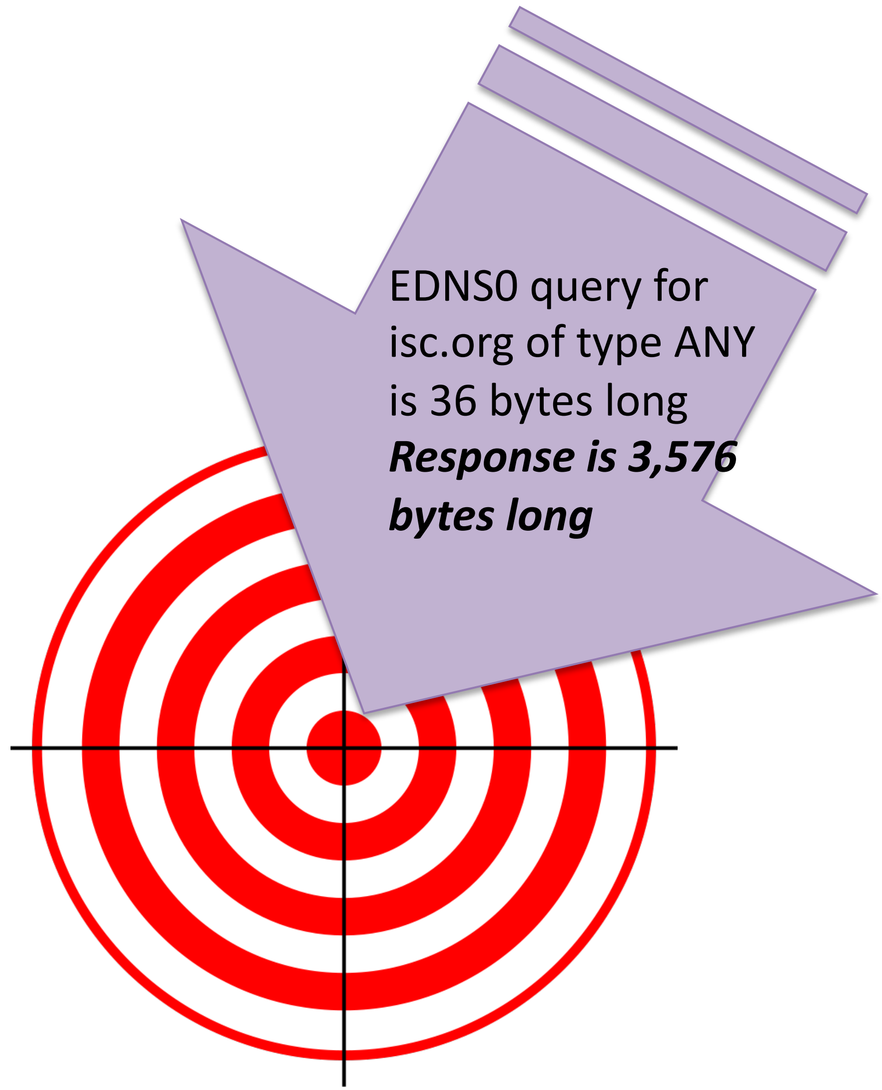
Cost of DDoS Attacks

- Revenue loss and lost sales
- Operational expenses related to downtime
- Decreased employee productivity
- Impact on customer experience
- Brand and reputation damage
- Breach of contract and violation of service level agreements

A SOLUTION

How did RRL come about?

- ISC signed our zones in 2006
- Observed queries that were occurring too frequently from the same IP
- Defensive strategy sessions at ISC with Paul Vixie led to RRL



Response Rate Limiting

- **An Enhancement to the DNS**
  - A mechanism for limiting the amount of unique responses returned by a DNS server
  - A mitigation tool for the problem of DNS Amplification Attacks
  - The only practical defense available for filtering in the name server
    - **BIND 9.9.4** includes RRL as a key feature
      - Available for download at https://www.isc.org/downloads/

Benefits of RRL

- Improved efficiency and ability to deflect attacks
  - Huge reductions in network traffic
  - Huge reductions in server load
- Brand protection
  - Servers are no longer seen as participating in abusive network behavior.
- Smoother network traffic
  - Impact on legitimate traffic has been minimal
  - Significant drop in attack traffic
  - No dropped DNS queries

Boundaries of RRL

- At present, RRL implementation is recommended for *authoritative servers only*.
- RRL cannot identify which source addresses are forged and which are not.
- We can use the information from pattern analysis to throttle responses
  - Incoming queries are **NOT** throttled by RRL

Use Case

- **Symptom:**
  – ISP identifies a significant increase in the number of queries
  – Attackers use ISP's response query to amplify attack
  – ISP's DNS infrastructure contributes to the attack

- **Solution:**
  – Network operator at ISP enables RRL
  – Defines parameters to mitigate queries and response time

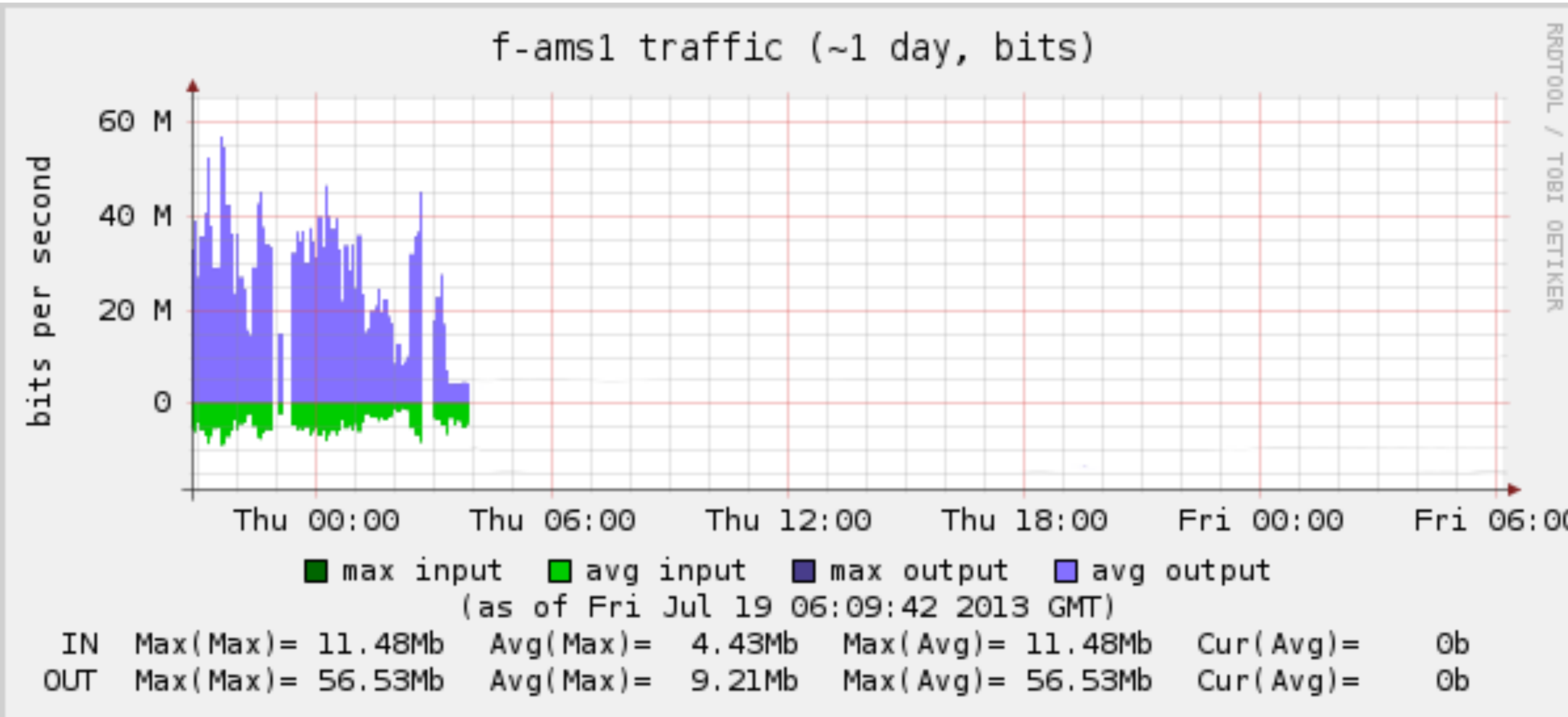
- **Result:**
  – ISP experiences huge reduction in traffic
  – Upholds positive corporate image; doesn't contribute to the attack

ISC RRL DEPLOYMENT EXPERIENCE

RRL on ISC's network

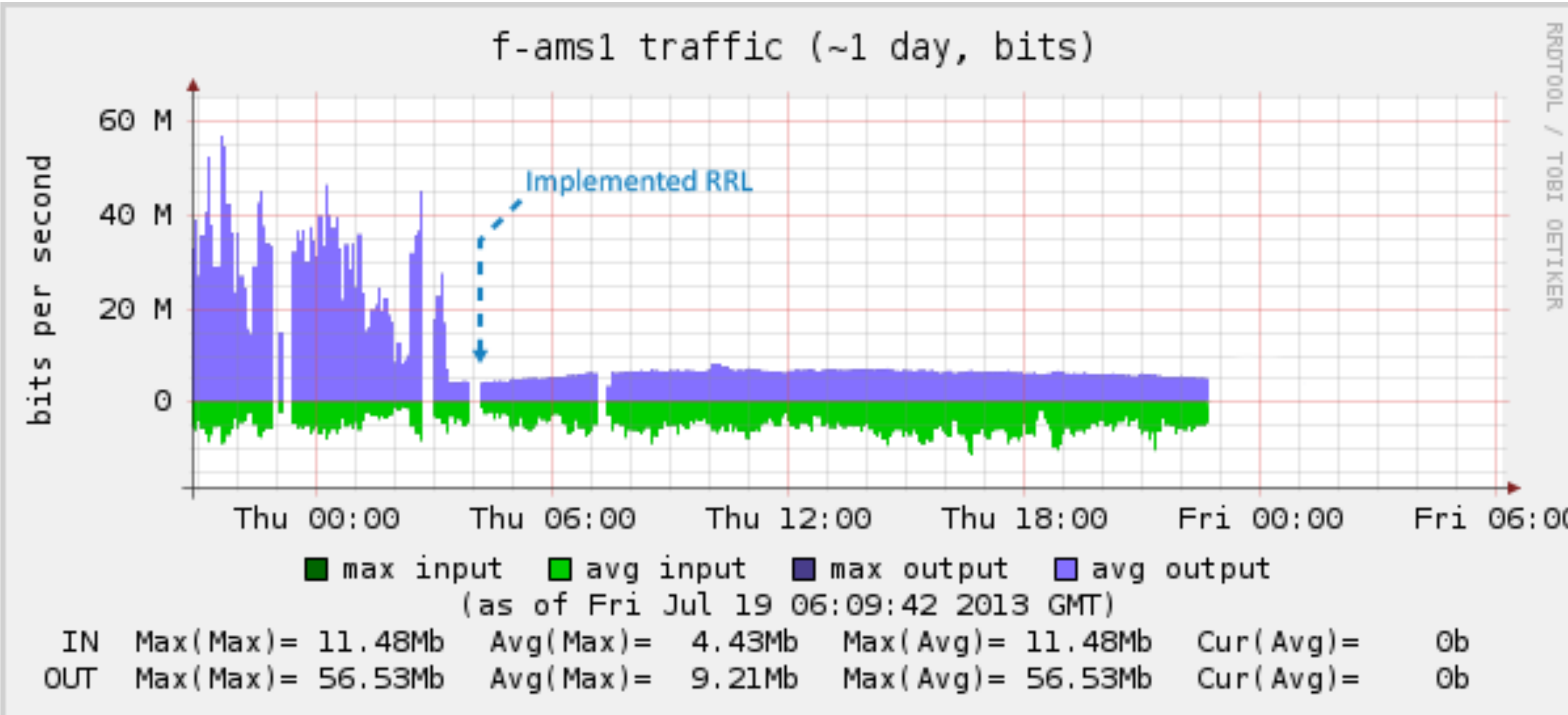
- Deployed on isc.org and SNS in Spring of 2012
- Deployed on F-root in Summer of 2013

ISC F-Root



f-ams1 traffic (~1 day, bits)
bits per second
60 M
40 M
20 M
0
Thu 00:00
Thu 06:00
Thu 12:00
Thu 18:00
Fri 00:00
Fri 06:00
RRDTOOL / TOBI OETIKER
max input
avg input
max output
avg output
(as of Fri Jul 19 06:09:42 2013 GMT)
IN Max(Max)= 11.48Mb Avg(Max)= 4.43Mb Max(Avg)= 11.48Mb Cur(Avg)= 0b
OUT Max(Max)= 56.53Mb Avg(Max)= 9.21Mb Max(Avg)= 56.53Mb Cur(Avg)= 0b

ISC F-Root



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Implemented RRL
Thu 00:00
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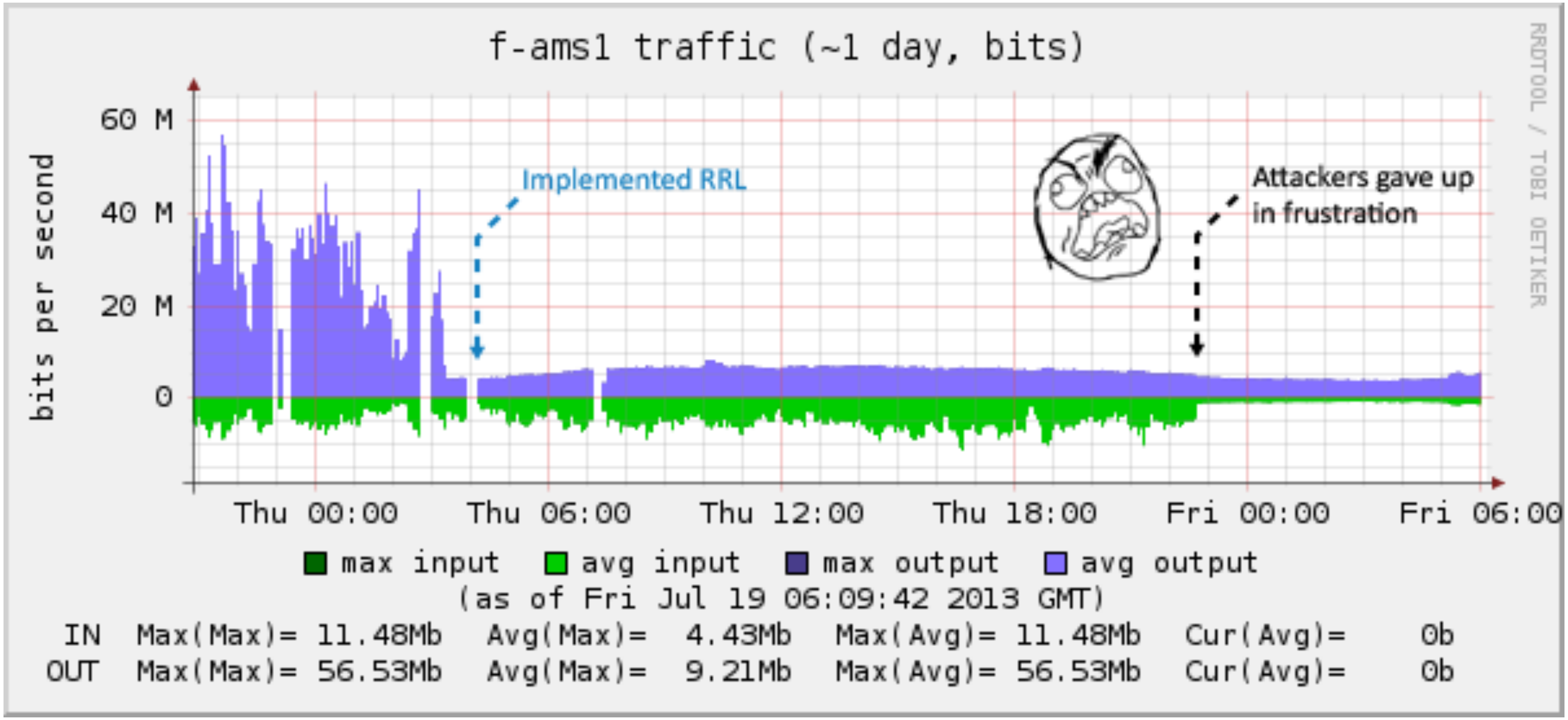

f-ams1 traffic (~1 day, bits)
bits per second
60 M
40 M
20 M
0
Implemented RRL
Attackers gave up
in frustration
Thu 00:00
Thu 06:00
Thu 12:00
Thu 18:00
Fri 00:00
Fri 06:00
max input
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RRDTOOL / TOBI OETIKER

ENABLING & CONFIGURING RRL IN BIND

Enabling RRL

- RRL is available in ISC's BIND 9.9.4 Software
  - **Download:** https://www.isc.org/downloads/
  - **RRL support must be enabled with –enable-rrl prior to compiling**
  - **Documentation:** https://kb.isc.org/article/AA-01000

```
options {
    directory "/var/named";
    rate-limit {
        responses-per-second 5;
#       log-only yes;
    };
};
```

K.I.S.S. (ISC's RRL deployment philosophy)

- SLIP
  - How many UDP requests can be answered with a truncated response.
  - Setting to "2" means every other query gets a short answer

  (**much more** on this topic later)
- Window
  - 1 to 3600 second timeframe for defining identical response threshold
  - Highly variable based on conditions
- Responses-per-second
  - How many responses per second for identical query from a single subnet
  - Highly variable based on conditions

```
rate-limit {
  slip 2;                      // Every other response truncated
  window 15;                   // Seconds to bucket
  responses-per-second 5;  // # of good responses per prefix-length/sec
```

```
rate-limit {
  slip 2;                  // Every other response truncated
  window 15;               // Seconds to bucket
  responses-per-second 5;  // # of good responses per prefix-length/sec
  referrals-per-second 5;  // referral responses
  nodata-per-second 5;     // nodata responses
  nxdomains-per-second 5;  // nxdomain responses
  errors-per-second 5;     // error responses
  all-per-second 20;       // When we drop all
```

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  all-per-second 20;      // When we drop all

  log-only no;      // Debugging mode
```

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  errors-per-second 5;     //          error responses
  all-per-second 20;       // When we drop all

  log-only no;             // Debugging mode
  qps-scale 250;           // x / query rate * per-second
                           //       = new drop limit
  exempt-clients  {127.0.0.1; 192.153.154.0/24;};
```

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rate-limit {
  slip 2;                 // Every other response truncated
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  log-only no;            // Debugging mode
  qps-scale 250;          // x / 1000 * per-second
                          //       = new drop limit
  exempt-clients  {  127.0.0.1; 192.153.154.0/24; 192.160.238.0/24  };
  ipv4-prefix-length 24;   // Define the IPv4 block size
  ipv6-prefix-length 56;   // Define the IPv6 block size
```

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rate-limit {
  slip 2;                  // Every other response truncated
  window 15;               // Seconds to bucket
  responses-per-second 5;// # of good responses per prefix-length/sec
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  exempt-clients  {  127.0.0.1; 192.153.154.0/24; 192.160.238.0/24  };
  ipv4-prefix-length 24;   // Define the IPv4 block size
  ipv6-prefix-length 56;   // Define the IPv6 block size

  max-table-size 20000; // 40 bytes * this number = max memory
  min-table-size 500;   // pre-allocate to speed startup
};
```

The SLIP=1 vs SLIP=2 debate

- ANSSI (CVE-2013-5661) recommends SLIP=1. Knot sets this as default.
- BIND & NSD defaults remain at SLIP=2

Let’s talk about why…

The SLIP=1 vs SLIP=2 debate

- The ANSSI (CVE-2013-5661) findings indicate SLIP=2 lowers the time needed for successful cache poisoning
- While an authoritative server is suppressing responses, an attacker has an increased window to send malicious "responses" to a resolver
- The findings aren't surprising or disputed, but the recommendation (SLIP=1) is…

Additional data for the SLIP debate

- The ANSSI tests weren't **just** Kaminsky-style attacks – but assumed only one authoritative nameserver in play due to SRTT trickery and/or Shulman fragmentation attack.
- 1 authoritative server, SLIP=2 lowered the time to successful poisoning from "days" to "hours". ~16 hours at 100Mbit/sec.

Additional data for the SLIP debate

- Further, we already have a solution for cache poisoning!

DNSSEC

- Of course, deployment remains a challenge.

Final thoughts on SLIP

- ISC decided to keep the default at SLIP=2 in BIND as we think this best provides protection against the problem RRL was designed to address.
- Your SLIP decision will be based on finding the right balance of competing security concerns in your environment.

Use of Logfiles

- Initially use logging
- Use a separate logging channel to segregate data from regular logs

Log only "dry run" feature to view behavior before going live with RRL

```
-=-
logging {

	channel query-error_log {
		file "log/query-error.log" versions 7 size 100M;
		print-category yes;
		print-severity yes;
		print-time yes;
		severity info;
	};
	category query-errors { query-error_log; };

};
```

Additional Considerations

- Window length – interrupt self-monitoring
  - Whitelist option ‘exempt clients’
- Not responding to legitimate queries

RRL Classifier

- **Expansion of RRL Basic**
  - RRL Basic filters on Destination Address of Response (source of attack traffic is assumed to be forged, but provides address of attack target)

- **2014**
  - Name Requested (QNAME)– allows for whitelisting and supports possible expansion to recursive use case
  - Size of the Response– limits amplification potential

Additional RRL General Information

- A Quick Intro to RRL: https://kb.isc.org/article/AA-01000/189/

- What is a DNS Amplification Attack: https://kb.isc.org/article/AA-00897

Additional RRL Advanced Information

- Response to SLIP issue
  - https://www.isc.org/blogs/cache-poisoning-gets-a-second-wind-from-rrl-probably-not/
- Vixie Article on DNS Security
  - http://www.circleid.com/posts/20130913_on_the_time_value_of_security_features_in_dns/

QUESTIONS?

Thank You

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For more information about RRL Basic, contact us at info@isc.org

For more information about RRL Classifier, contact us at info@dns-co.com

Internet Systems Consortium