DNS Response Rate Limiting

LISA14

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About the Presenter

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

ISC at a Glance

Open Source	• BIND DNS server • ISC DHCP client, relay, server • Kea new DHCP server
Network Services	• F-Root, one of 13 root server systems world-wide • Hosted@, public-benefit hosting
Commercial Services	• Subscription Support Services • BIND and DHCP • 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

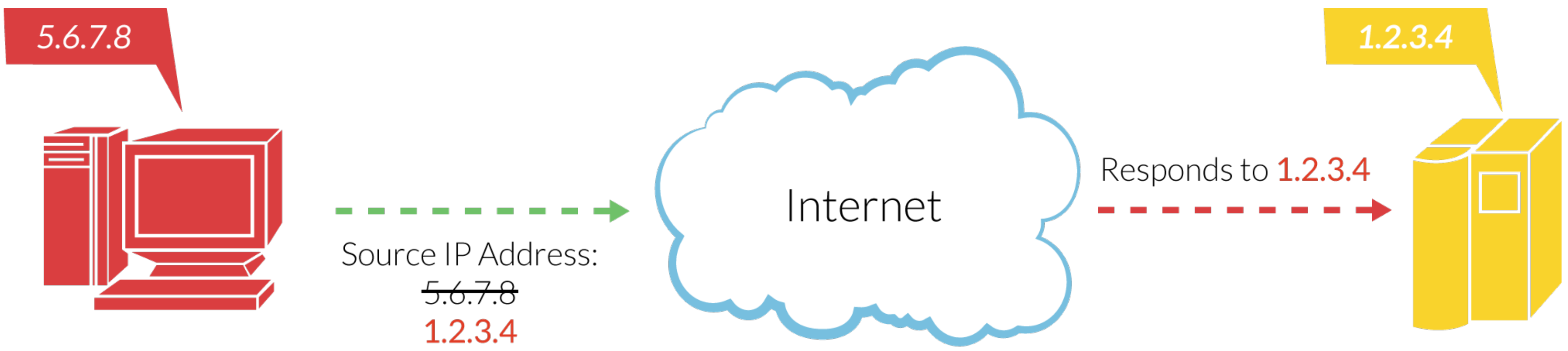
  2. Attacker searches for responses that are several times bigger than the request

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

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

Accidental(?) DNS Attacks

Poor Network Hygiene

- Non-caching name servers
- Too frequent flushing
- Open recursive servers (some ~25-30 Million, in fact!)

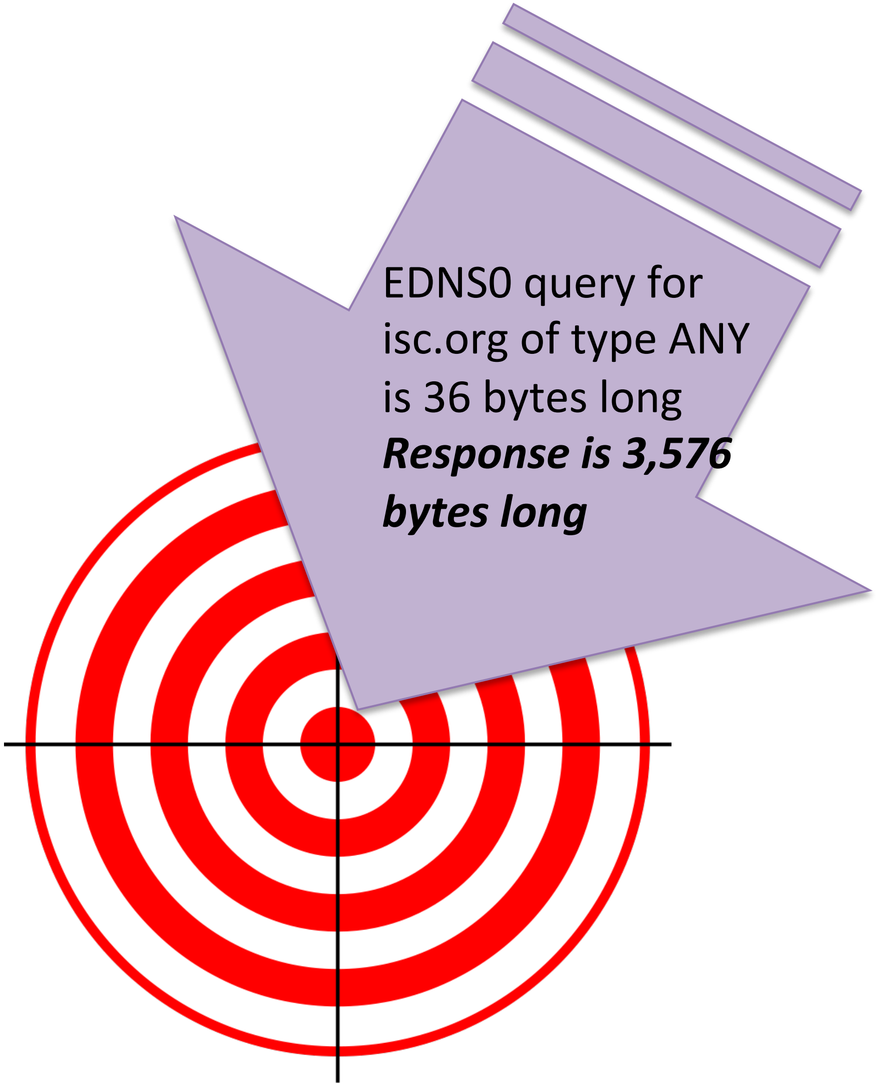
Cost of DDoS Attacks

- 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 ON THE AUTHORITATIVE SIDE OF THINGS…

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

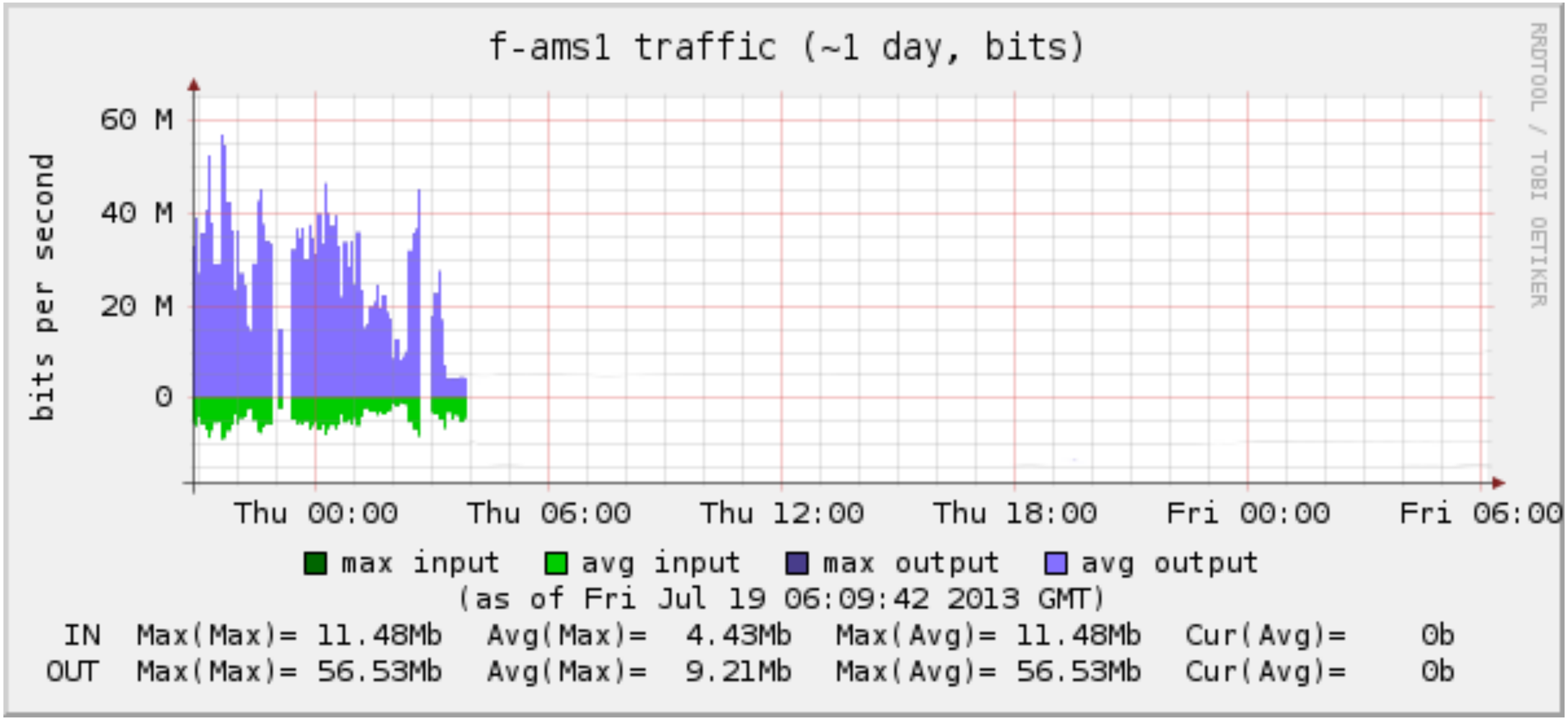
- **Result:**
  - ISP experiences huge reduction in traffic
  - Upholds positive corporate image; doesn't contribute to the attack

ISC RRL DEPLOYMENT EXPERIENCE

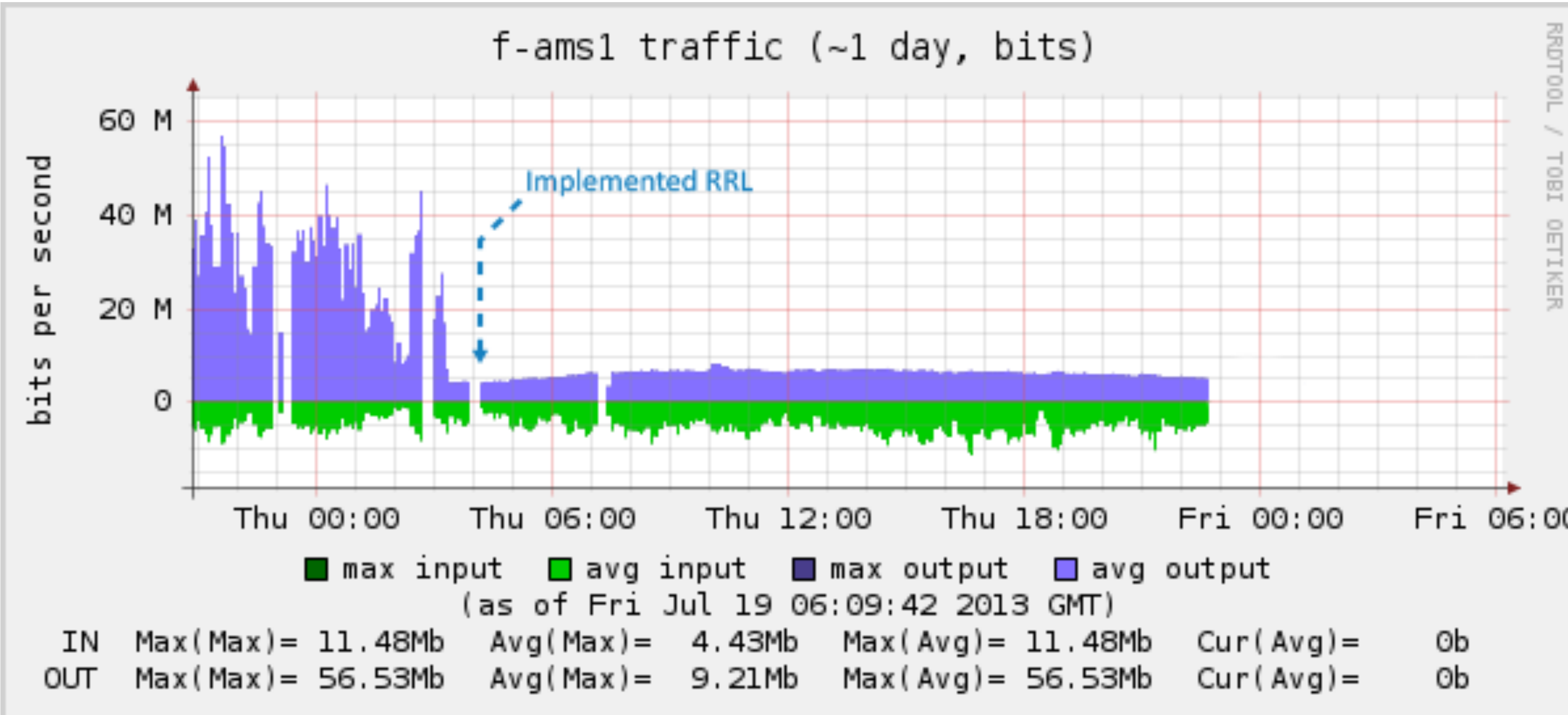
RRL on ISC's network

- 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



f-ams1 traffic (~1 day, bits)
bits per second
60 M
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20 M
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Implemented RRL
Thu 00:00
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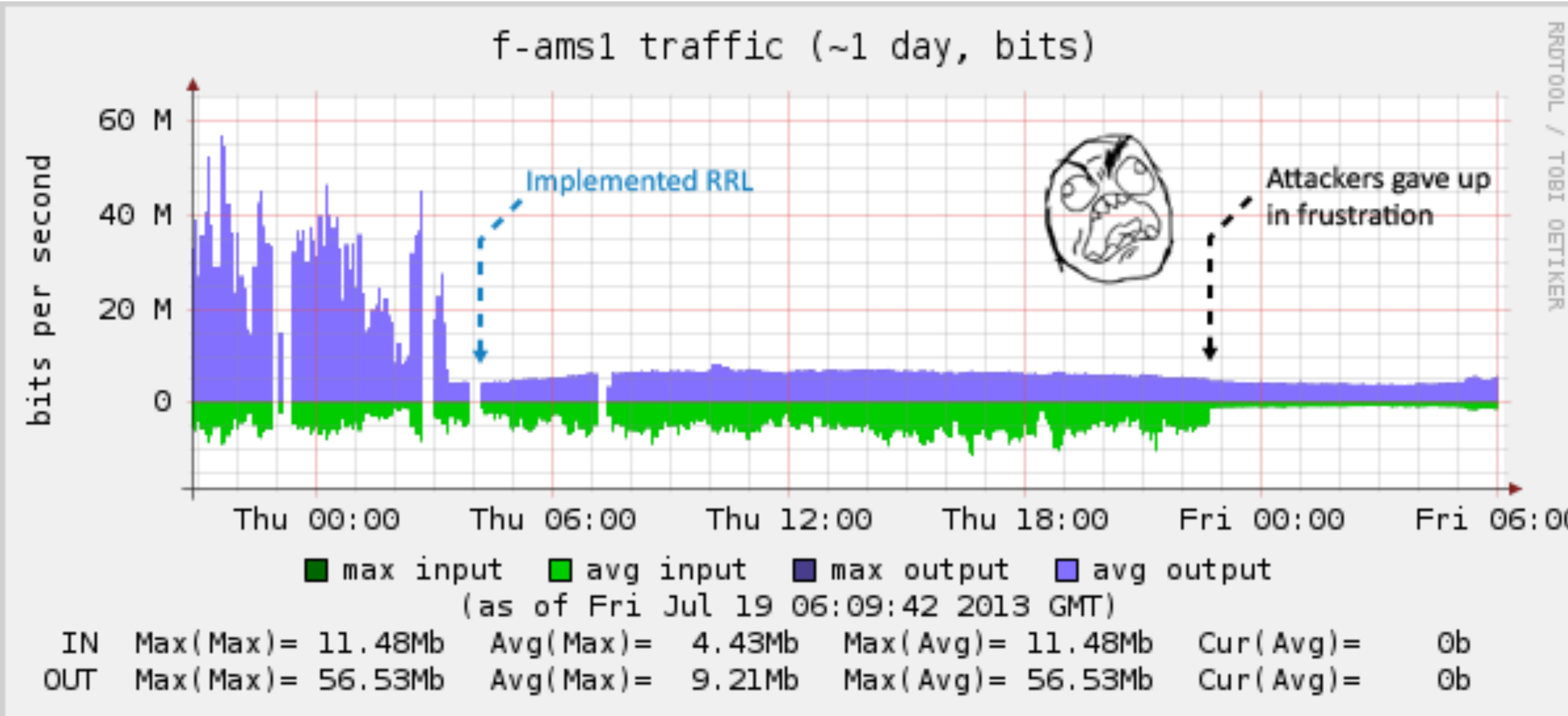

f-ams1 traffic (~1 day, bits)
bits per second
60 M
40 M
20 M
0
Implemented RRL
Attackers gave up in frustration
Thu 00:00
Thu 06:00
Thu 12:00
Thu 18:00
Fri 00:00
Fri 06:00
max input
avg input
max output
avg output
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RRDTOOL / TOBI OETIKER

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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  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;};
```

```
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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  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
```

```
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
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                          //       = 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

  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

- Well… 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/

WHAT ARE WE SEEING & DOING ON THE RECURSIVE SIDE?

What are we seeing on the recursive side these days?

- ‘Collateral Damage’ Client DDoS traffic

  <randomstring>.www.abc123.com
  <anotherstring>.www.abc123.com

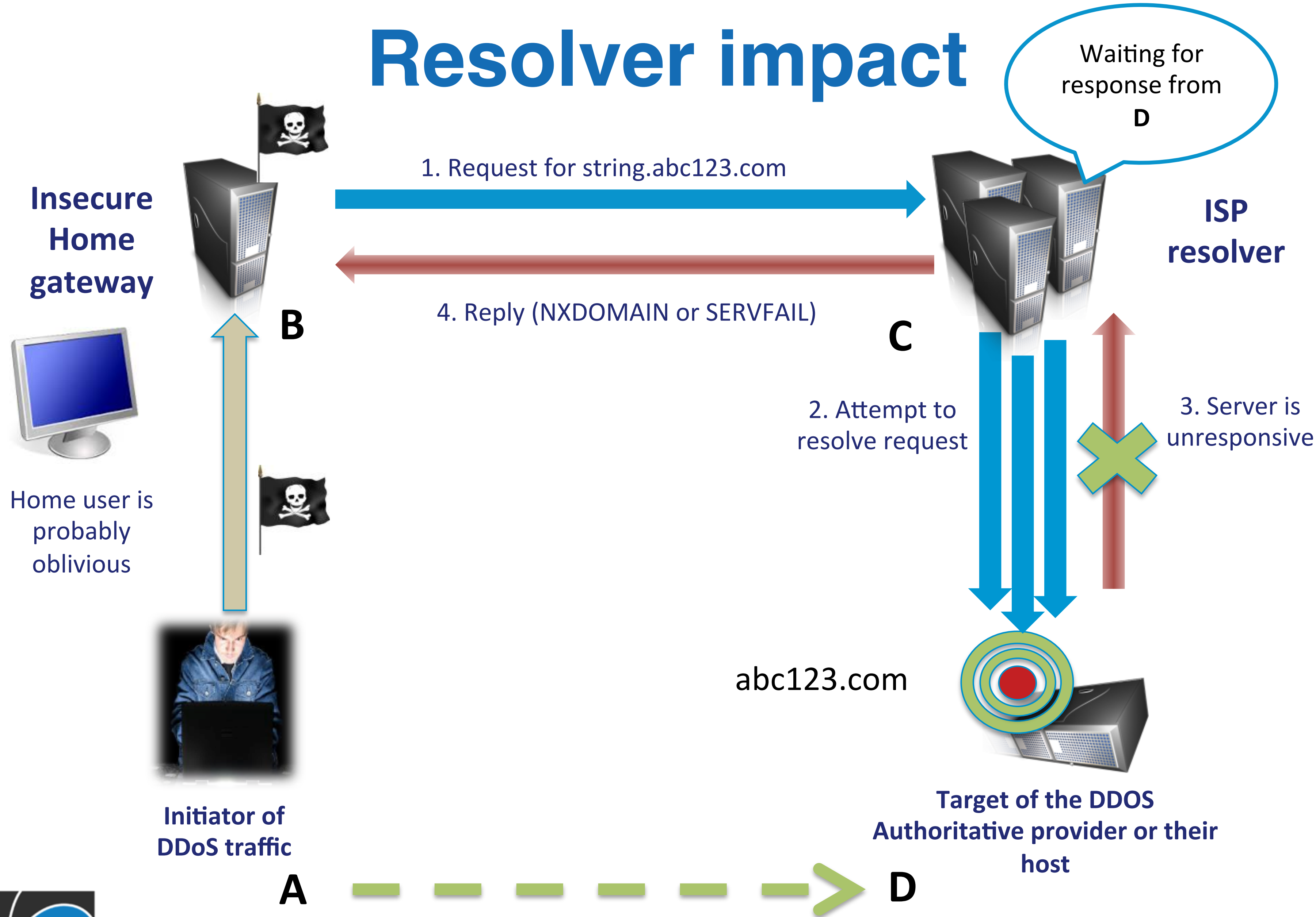
The queries are unique and originate from a large range of different client addresses. Typically, the servers for abc123.com do not respond at all, or only sporadically to the recursive server handling the client query.

A flurry of queries will run for a day or two, then stop. The domains are genuine, and the majority appear to be for online commercial sites, often hosted in China.

Problem statement

- Authoritative servers under attack are non-responsive and tie up resolver resources wanting for replies
- So far, the impact on recursive server resources appears to be accidental - primarily due to open resolvers.
- This is a wake-up call that we need to better manage recursive resources

Resolver impact



Mitigation Approaches

- Traffic patterns impacting all recursive servers (not just BIND)
- Mitigations suggested/introduced:
  - Network infrastructure/environment
  - Some generic to all DNS servers
  - Some specific to BIND (currently experimental) but could be adopted by other DNS server software manufacturers.

Mitigation Approaches - 1

- Eliminate open resolvers
  - Is your recursive server an open resolver?
  - Open client CPE devices
  - Small business users forwarding local open caches to your servers
- Compromised/infected clients
  - ‘hearsay’ evidence that these exist now
  - But it’s only a matter of time…

Mitigation Approaches – 2

- Locally-created authoritative answers
  - Detect ‘bad’ domain names
  - Make recursive server temporarily authoritative for the domain being used
  - *Prevents valid queries (which wouldn’t succeed anyway)*
  - *Problem of false-positives – might need white-lists if using scripted detection*
  - *Need to undo the mitigation afterwards*

Mitigation Approaches – 3

- Response Policy Zones (DNS-RPZ)
  - Detect ‘bad’ domain names
  - Update RPZ zone to blacklist domains
  - *Prevents valid queries (which wouldn’t succeed anyway)*
  - *Problem of false-positives – might need white-lists if using scripted detection*
  - *Need to undo the mitigation afterwards*

Experimental Approaches – 1

- Hold-down Timer *(since writing, deprecated and replaced with fetches-per-server)*
  - One timer each per server per zone
  - Count how many consecutive times a server fails to respond (***holddown-threshold***)
  - When threshold reached, don't send queries to that server for ***holddown-timer*** seconds (doesn't abort any currently waiting queries)
  - Quick check – if next 'response' from server is a timeout, then hold-down immediately
  - Helpful, but less effective with intermittent outages.

Experimental Approaches – 2

- Rate limiting ***fetches-per-server***.
  - *Configurable upper limit (default 0 = unlimited)*
  - *Per-server quota dynamically re-sizes itself based on the ratio of timeouts to successful responses*
  - *Completely non-responsive server eventually scales down to fetches quota of 2% of configured limit.*

Experimental Approaches – 3

- Rate-limiting ***fetches-per-zone***
  - Similar to clients-per-query
  - Works with unique clients
  - Tune larger/smaller depending on normal QPS to avoid impact on popular domains
  - Could be less effective against non-responding server for many zones

QUESTIONS?

Thank You

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

Internet Systems Consortium