Network Security

DNS (In)security

Radboud University, The Netherlands

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- `iptables` can also be used for NAT (and port forwarding)
- Tunneling can be used to circumvent a packet filter

DNS and domain names

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- Administration of top-level domains by Internet Corporation for Assigned Names and Numbers (ICANN)
- Administrations of domains below a TLD by registries, e.g., Stichting Internet Domeinregistratie Nederland (SIDN) for `.nl`

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DNS servers and requests

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- Recursive request (to a DNS cache): give me the answer or an error
- Iterative request (to an authoritative server): give me the answer or tell me who might know

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- 131.174.117.20 tells your client (e.g., SSH client) the IP address of `sandor.cs.ru.nl`

DNS entry types

Type	Meaning
A	Address record: returns a 32-bit IP address, used to map hostnames to addresses
NS	Nameserver: Lists the authoritative nameservers of a DNS zone
CNAME	Canonical Name: Assigns a hostname alias to a hostname
SOA	"Start Of Authority": Lists authoritative information about the zone: primary DNS server, mail address of administrator (with @ replaced by a .), serial number, refresh times and timeouts.
MX	Mail Exchanger: Gives a mail server responsible for the domain
TXT	Text field: Originally arbitrary human-readable text, today often used for machine-readable data

DNS entry types

- Four sections in a DNS reply:
  - The QUESTION SECTION (repetition of the question)
  - The ANSWER SECTION
  - The AUTHORITY SECTION
  - The ADDITIONAL SECTION
- ADDITIONAL SECTION is particularly important for *glue records*: communicate IP addresses of authoritative DNS servers

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  - Ask `ns1.science.ru.nl` for all information of `science.ru.nl`

    ```
    dig @ns1.science.ru.nl science.ru.nl ANY
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  - Reverse lookup hostname for 131.174.142.4:
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    dig -x 131.174.142.4
    ```
- Find out about ICANN registration information of a domain: `whois`, e.g.:
  ```
  whois cryptojedi.org
  ```

The DNS root servers

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- DNS root servers are extremely critical piece of Internet infrastructure
- How many are there? Answer: 13
- Names of these servers: `a.root-servers.net` ... `m.root-servers.net`
- Those servers are actually highly redundant, some even distributed over the globe
- Example: K-root server, run by RIPE-NCC
  - Used to be in Amsterdam
  - Now at 18 different locations

The DNS root servers

DNS root servers hit by largest DDoS ever

News By Oct. 23, 2002 12:38 pm

The largest Distributed Denial of Service (DDoS) attack in history went largely unnoticed by the general public on October 21, 2002, but it was almost a disaster, say several Internet backbone operators.

Around 5:00 P.M. Eastern time, the root servers that handle domain name resolution for all top-level domains on the Internet were subjected to an hour-long attack by thousands of "zombie" computers–PCs that have been co-opted by a hacker into participating in an attack without the knowledge of the PC owner. Of the 13 root servers in existence, only four were able to keep operating during the attack. Had the attack continued for much longer, experts say, the remaining servers may have been overwhelmed, effectively strangling the entire root Domain Name Server (DNS) system. Although many ISPs and companies maintain

http://www.geek.com/news/dns-root-servers-hit-by-largest-ddos-ever-550549/

The DNS root servers

Topic: *Security* *Follow via:*

DNS root server attack launched from Germany

Summary: *According to a published report, the recent attack against the DNS root servers was launched from a host server in Germany that controlled millions of zombie machines in South Korea*

By Ryan Naraine for Zero Day | February 22, 2007 -- 09:41 GMT

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The distributed denial-of-service attack against the DNS root servers earlier this month was launched from a host server in Germany that controlled millions of zombie machines in South Korea, according to a report in The Korea Times.

Details of the cross-continent attack, which almost took out three of the 13 official root DNS servers are beginning to surface with South Korea's ministry of information and communication confirming that a host server in Coburg, Germany ordered hijacked Windows machines in Korea to stage the attacks.

http://www.zdnet.com/blog/security/dns-root-server-attack-launched-from-germany/50

The DNS root servers

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Home / Reviews / Software / Security / Anonymous' 'Operation Blackout' Goes Dark; DNS Just Fine

Anonymous' 'Operation Blackout' Goes Dark; DNS Just Fine

BY DAVID MURPHY   MARCH 31, 2012 01:08PM EST   7 COMMENTS

It doesn't appear as if Web browsing will be affected today, as Anonymous is likely not launching an attack on the Web's root DNS servers.

1.9K SHARES

http://www.pcmag.com/article2/0,2817,2402469,00.asp

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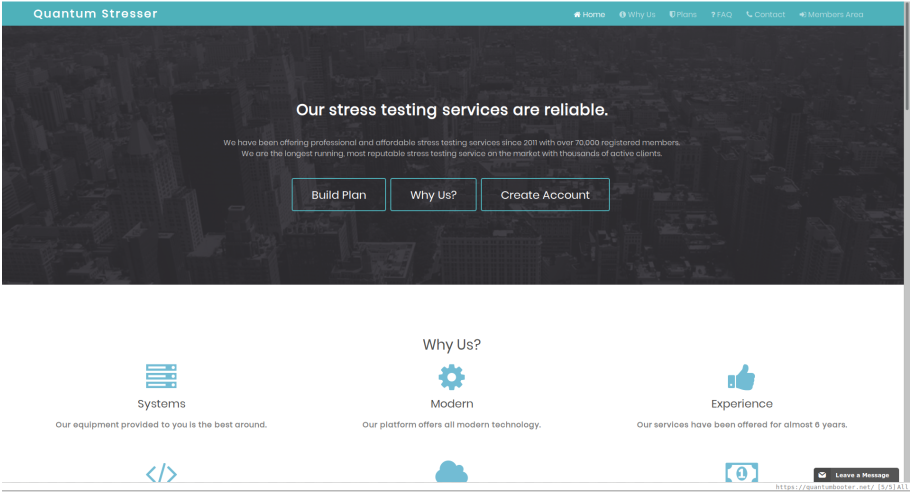
- This is slow (small payload, UDP is not reliable)
- Ready-made client/server: `ozymandns` by Kaminsky: http://dankaminsky.com/2004/07/29/51/
- Tutorial for DNS tunneling (with `ozymandns`): http://dnstunnel.de/

DNS DDoS amplification

- DNS (typically) uses UDP
- No session establishment: send request, get answer
- Answer can be much larger than the request
- Idea: Spoof IP address of DOS victim in DNS request
- Victim will receive much more data than attacker has to send
- This is called *DNS (D)DOS amplification*

DNS DDoS amplification



DNS DDoS countermeasures?

- Very hard to defend against DDOS (and DNS amplification)
- Can (temporarily) block packets from open DNS servers
- Can (temporarily) block large DNS reply packets
- Can try to filter spoofed IP addresses (“ingres and egress filtering”)

DNS spoofing

- Probably most obvious DNS attack: send wrong answer
- Send wrong answer to client: hit one target
- Send wrong answer to DNS cache: hit many targets
- Answers contain “validity period”
- It’s possible to poison DNS caches for a pretty long time

In the old days

```
$ dig @ns1.attacker.com www.attacker.com
    ;; ANSWER SECTION:
    www.attacker.com.    120      IN    A    123.45.67.8

    ;; AUTHORITY SECTION:
    attacker.com.        86400    IN    NS   ns1.attacker.com.

    ;; ADDITIONAL SECTION:
    ns1.attacker.com.    604800   IN    A    123.45.67.89
    www.target.com.       43200   IN    A     66.66.66.66
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The bailiwick check

- Idea of the attack: wrong entry for `www.target.com` ends up in cache
- Countermeasure (since 1997): use *bailiwick* check
- Reject ADDITIONAL information if the requested server is not authorized to answer for the domain

Short interlude: A bailiwick

Definition of BAILIWICK

1. the office or jurisdiction of a bailiff
2. a special domain

Source: http://www.merriam-webster.com/dictionary/bailiwick

Short interlude: A bailiwick

Definition of BAILIFF

1. **a:** an official employed by a British sheriff to serve writs and make arrests and executions
   b: a minor officer of some United States courts usually serving as a messenger or usher
2. chiefly British: one who manages an estate or farm

Source: http://www.merriam-webster.com/dictionary/bailiff

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- Attacker can send *many packets*
- Attacker can also try to run DOS against real DNS server

Kaminsky's attack (2008)

- Idea: Use website with many links on *subdomains*:

```
<img src="http://aaaa.target.com/image.jpg"/>
<img src="http://aaab.target.com/image.jpg"/>
<img src="http://aaac.target.com/image.jpg"/>
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- Victim will request all of those subdomains, race for each query

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- Idea: Use website with many links on *subdomains*:

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- Victim will request all of those subdomains, race for each query
- Attacker crafts answer packet for each of those requests:

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    target.com.         86400    IN    NS   ns.target.com.

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- The client requested the IP address with `target.com` domain
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- The value 604800 defines the validity period of the information: 7 days

Impact of Kaminsky's attack

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The Top Five Worst DNS Security Incidents

By Ram Mohan on August 11, 2010

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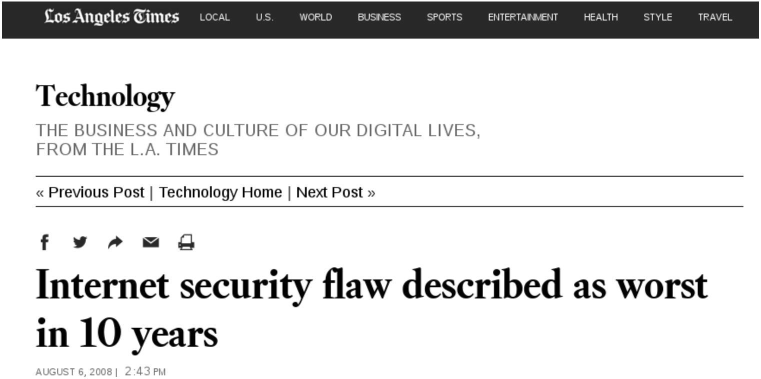
1. "The Kaminsky Bug" puts the whole Internet at risk

Often regarded as possibly the greatest security threat the Internet has ever faced, the so-called "Kaminsky Bug" emerged in July 2008, creating great unease and even greater hype. Researcher Dan Kaminsky discovered that it was easy to exploit a weakness in the DNS and built the software to do it. This weakness would enable malicious hackers to transparently imitate any Web page or e-mail account by poisoning the DNS information cached by Internet service providers.

Impact of Kaminsky's attack



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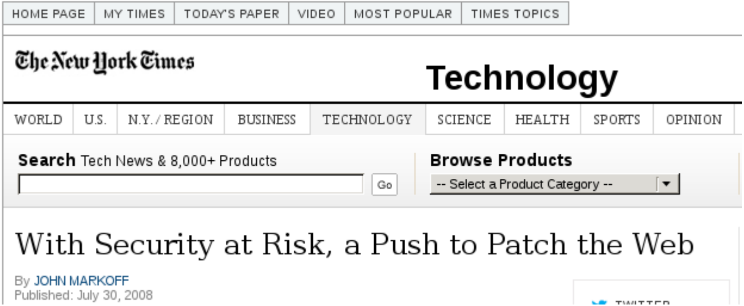

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With Security at Risk, a Push to Patch the Web

By JOHN MARKOFF
Published: July 30, 2008

http://www.nytimes.com/2008/07/30/technology/30flaw.html?pagewanted=all

Source-port randomization

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- Today, all DNS servers randomize the source port
- Potential problem with NAT: source port is rewritten

Birthday attacks

- Imagine that a DNS server is sending out many *identical requests* (with different source port and QID)
- Attacker spoofs replies with different port+QID combinations
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Birthday attacks

- Imagine that a DNS server is sending out many *identical requests* (with different source port and QID)
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- Any collision with one of the requests wins
- Do servers send out identical requests?
- Some do, e.g., `djbdns`'s `dnscache` (Kevin Day, 2009):
  - Trigger 200 identical queries (default size of query queue)
  - Need to be fast, send these queries before first reply is received
  - Increase attacker's success probability from $1/2^{32}$ to $200/2^{32}$

More randomization?

- The QUESTION section of a DNS request is copied to the reply
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  `www.ExAMPle.com` is the same as `www.example.com`
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- Slight problem: DNS standard does not *require* the QUESTION section to be copied bit-by-bit
- Other idea: query repetition (another 32 bits of entropy)
- Adds additional complications (not broadly implemented)
- Bernstein on randomization:

  "It is clear that enough randomization effort would be able to stop all blind forgeries."

The easy way. . .

- A passive MitM can read DNS requests
- Becoming a passive MitM is not that hard:
  - Sniff WiFi
  - ARP spoofing
  - Be an ISP
  - Be a network administrator in a company
- A DNS attacker can poison a DNS cache
- Affects many more clients than a MitM between clients!

DNS censorship

- DNS can be used for censorship:
  - April 1997: German provider DFN blocks IPs of xs4all.nl
  - German "Zugangserschwerungsgesetz"
  - "Child Sexual Abuse Anti Distribution Filter" (CSAADF) by CIRCAMP used in Denmark, Finland, Italy, Newzealand, Norway, Sweden und der Switzerland
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  - Circumvention: Use alternative DNS

Source: http://xkcd.com/1361/

DNSSEC

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- Additional (cryptographic) information in new DNS entry types:
  - RRSIG: DNSSEC signature
  - DNSKEY: public key to verify signature

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- DNSSEC does not increase the size of DNS requests
- DNSSEC does significantly increase the size of DNS replies
- Modern DDOS uses DNS+DNSSEC
- RFC 4033: "DNSSEC provides no protection against denial of service attacks. Security-aware resolvers and security-aware name servers are vulnerable to an additional class of denial of service attacks based on cryptographic operations."

DNS zone enumeration

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- RFC 4033: "DNSSEC introduces the ability for a hostile party to enumerate all the names in a zone by following the NSEC chain."

NSEC3

- Idea: Hash domain names, sign information on gaps between existing *hashes*
- Example:
  - request for (non-existing) `test.example.com`
  - Hash `test.example.com` (with SHA-1), obtain: `401f83bc96721eeeba6f5c1c54cf0a83dc08a30b`
  - Signed answer: "There is no name with hash between `068503358dddd23cf6cf00f5d6ad9a45cd0a8e03` and `512e9305c87f4f1ccdbacb80c559f3dce496ae29`.

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- Software by Niederhagen: Try 6000 billion hashes per week on NVIDIA GTX295 GPU
- This is *much* faster than trying domain names through DNS queries

More DNSSEC problems

- Second implication of offline-signed records: *replay attacks*
- Attack scenario:
  - Company runs server `www.example.com` at 123.45.67.89
  - DNS server sends signed name resolution for this name/IP, attacker records it
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- DNSSEC does not encrypt queries; from RFC 4033:
  "Due to a deliberate design choice, DNSSEC does not provide confidentiality"

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- Addional disadvantage: It's much easier to deploy than DNSSEC, does not create as many jobs for consultants

More reading...

- Dan Bernstein about DNSCurve (and DNSSEC vulnerabilities):
  - http://dnscurve.org/
  - http://cr.yp.to/talks/2010.12.28/slides.pdf
  - Updated: http://cr.yp.to/talks/2016.12.08/slides-djb-20161208-dnssec-a4.pdf
- Dan Kaminsky's answer:
  http://dankaminsky.com/2011/01/05/djb-ccc/

  "DNSSEC Is Not Necessarily An Offline Signer – In Fact, It Works Better Online!"
- Dan Bernstein's answer:
  http://marc.info/?l=djbdns&m=129434351607605&w=2