Internet security

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Thanks to:
NSF ITR–0716498

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Indeed, many connections
use SSL, Skype, etc.
But *most* connections don't.

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In fact, attackers are forging packets *and* exploiting buffer overflows *and* doing much more. Users want *all* of these problems fixed.

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True for most protocols.
But let's focus on HTTP.
Most HTTP servers and browsers (Apache, Internet Explorer, Firefox, etc.) support SSL.

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Indeed, usability is a major issue. Only $\approx$1% of the Apache servers on the Internet have SSL enabled.

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If you connect to
`https://www.google.com`,
Google redirects your browser to
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"Enabling SSL
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Google doesn't want to pay for
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Many companies sell
SSL-acceleration hardware,
but that costs money too.

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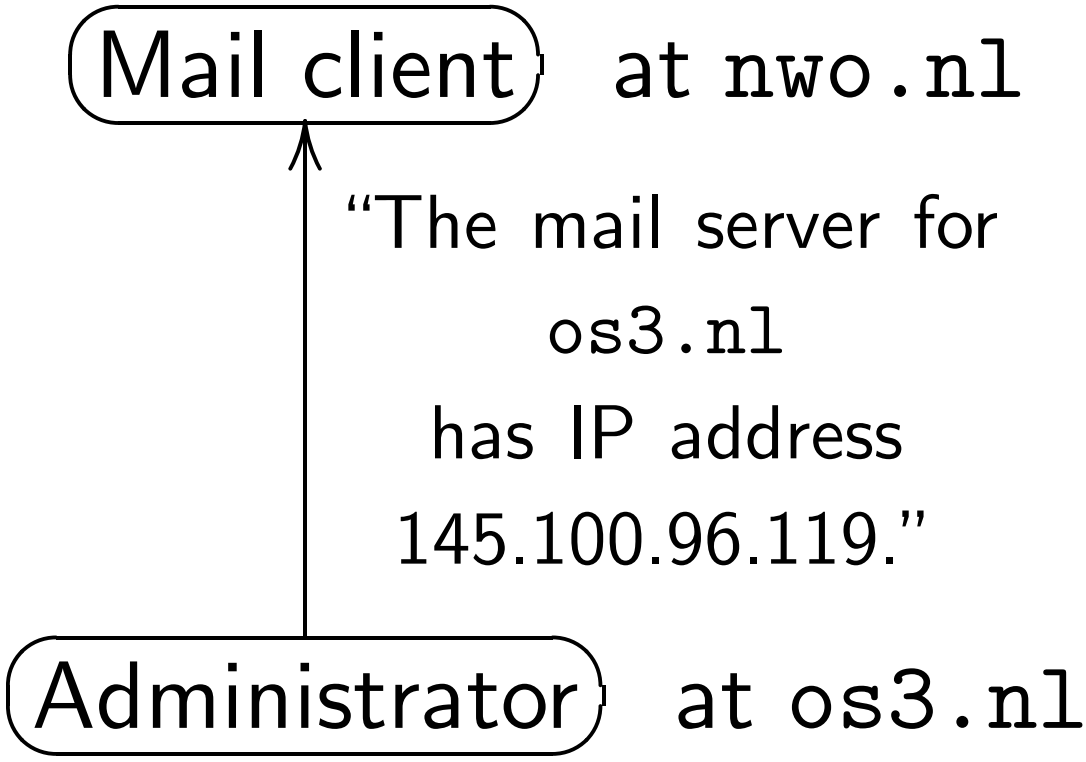
to protect every Internet packet?

Can universal crypto be *usable*?

The Domain Name System

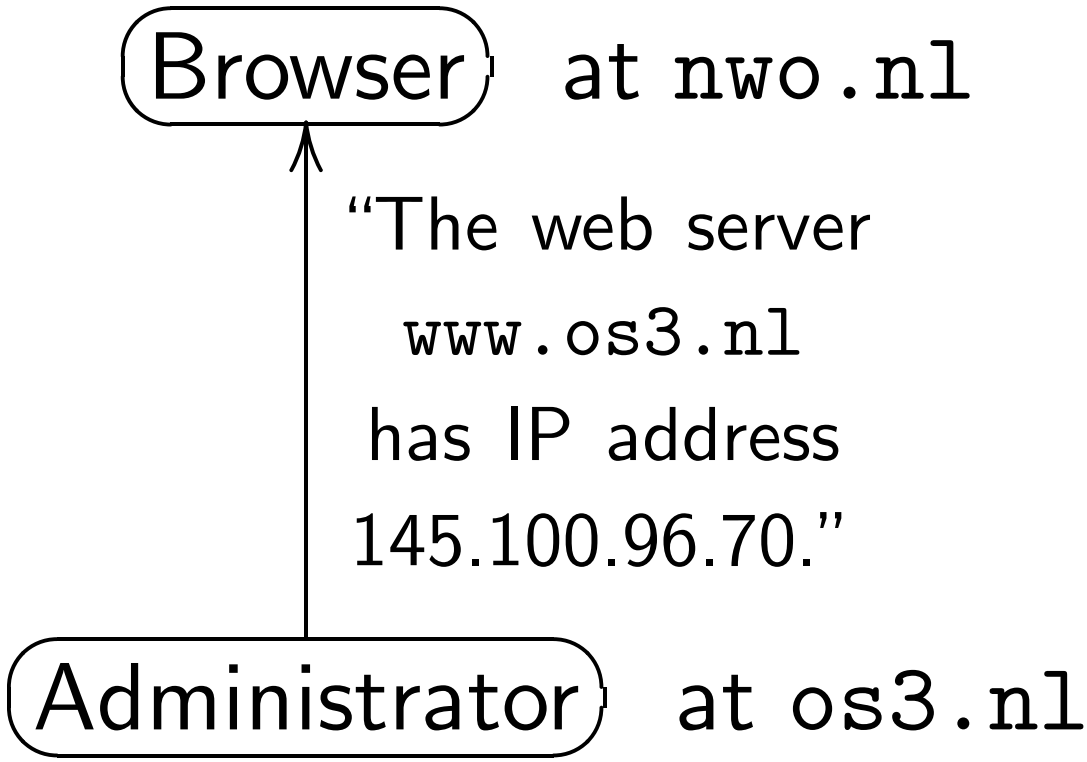
`nwo.nl` has mail
to deliver to `someone@os3.nl`.



Now `nwo.nl`
delivers mail to
IP address 145.100.96.119.

Same for web browsing.

`nwo.nl` wants to see
`http://www.os3.nl`.



Now `nwo.nl`
retrieves web page from
IP address 145.100.96.70.

DNS software security holes:
BIND libresolv buffer overflow,
Microsoft cache promiscuity,
BIND 8 TSIG buffer overflow,
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But what about *protocol* holes?

Forging DNS packets

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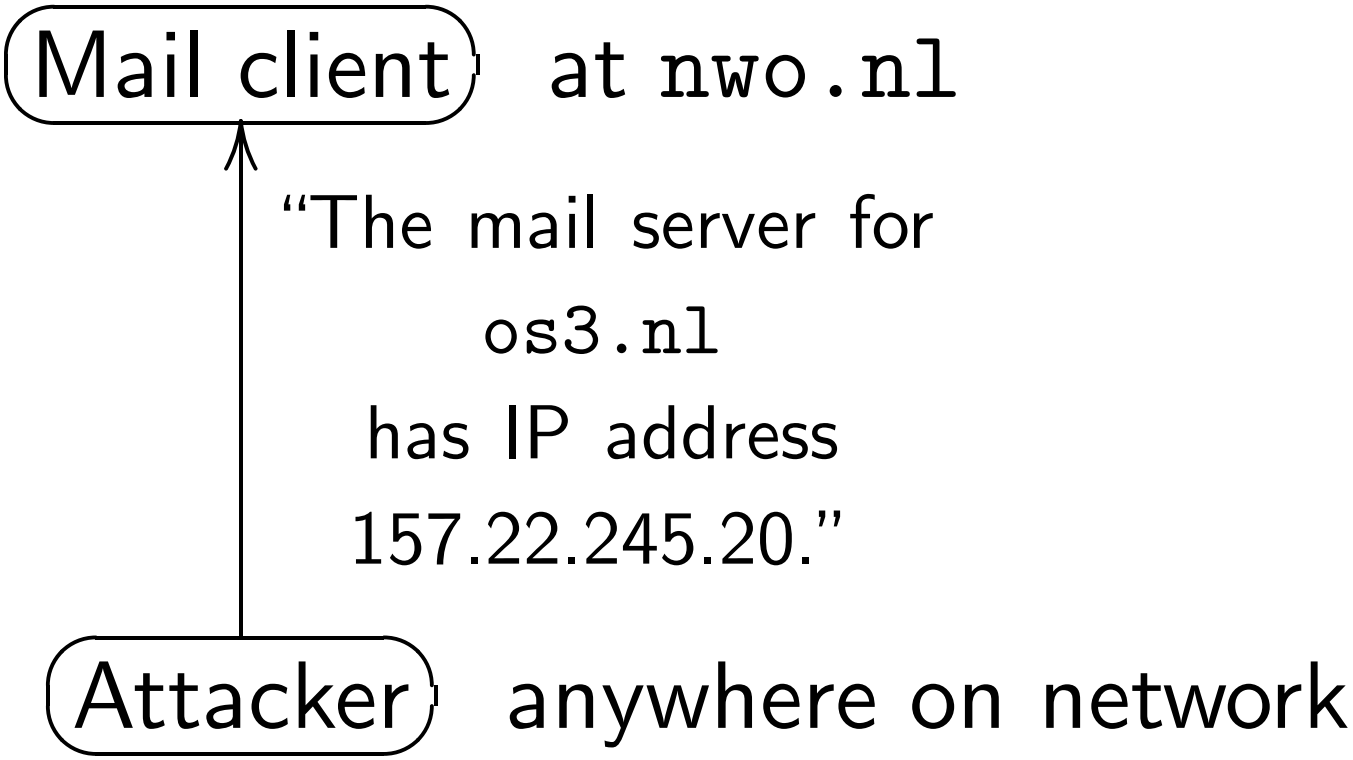

Now `nwo.nl`
delivers mail to
IP address 157.22.245.20,
actually the attacker's machine.

“Can attackers do that?”

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— Yes.

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“Really?”

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— Yes, but the attacker
forges the sender address;
as easy as forging address
on a physically mailed letter.

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Sniff the network.

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What about cookies?

Client's DNS query packet contains a 16-bit ID.

RFC 1035 (1987): "This identifier is copied [to the] reply and can be used by the requester to match up replies to outstanding queries."

Traditional ID sequence:
1, 2, 3, 4, 5, etc.

More recent idea:
"Hey, let's use random IDs! Then the attacker won't be able to forge a packet with the right ID!"

Many “random” IDs
are actually quite easy to predict.
Client asks for information
from attacker’s servers;
attacker inspects IDs,
predicts subsequent IDs.

See, e.g., emergency BIND 9
upgrade (2007.07.24) responding
to an attack by Amit Klein.

But modern cryptographic
random-number generators
are extremely difficult to predict.

Client can randomize
16-bit ID *and*
16-bit UDP source port.

Implemented and advertised
in `djbdns` since 1999,
and in PowerDNS since 2006.

Same feature added 2008.07
in emergency upgrade to BIND,
Microsoft DNS, Nominum CNS,
most Cisco products, etc.

New York Times headline:
"WITH SECURITY AT RISK,
A PUSH TO PATCH THE WEB"

Many ways for attackers
to beat this randomization,
even if it's cryptographic:

1. Attack repeatedly.
"An attacker who makes a few
billion random guesses is likely
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with a colliding attack;" etc.

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What about serious crypto?

Cryptography can
stop sniffing attackers
by scrambling legitimate packets.

Cryptography is often described
as protecting confidentiality:
attackers can't understand
the scrambled packets.

Can also protect integrity:
attackers can't figure out
a properly scrambled forgery.

Traditional cryptography requires each legitimate client-server pair to share a secret key.

Public-key cryptography
has much lower requirements.
(1976 Diffie–Hellman;
many subsequent refinements)

Each party has one public key.
Two parties can communicate
securely if each party knows
the other party's public key.

1993: IETF begins "DNSSEC"
project to add public-key
signatures to DNS.

Paul Vixie, June 1995:

> This sounds simple but it has deep reaching consequences in both the protocol and the implementation—which is why it's taken more than a year to choose a security model and design a solution. We expect it to be another year before DNSSEC is in wide use on the leading edge, and at least a year after that before its use is commonplace on the Internet.

BIND 8.2 blurb, March 1999:

> [Top feature:] Preliminary DNSSEC.

BIND 9 blurb, September 2000:

> [Top feature:] DNSSEC.

Paul Vixie, November 2002:

> We are still doing basic research on what kind of data model will work for DNS security. After three or four times of saying "NOW we've got it, THIS TIME for sure" there's finally some humility in the picture . . . "Wonder if THIS'll work?" . . .
>
> It's impossible to know how many more flag days we'll have before it's safe to burn ROMs . . . It sure isn't plain old SIG+KEY, and it sure isn't DS as currently specified. When will it be? We don't know. . . .
>
> 2535 is already dead and buried. There is no installed base. We're starting from scratch.

Paul Vixie, 20 April 2004, announcing BIND 9.3 beta:

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>
> . . .
>
> ISC will also begin offering direct support to users of BIND through the sale of annual support contracts.

Paul Vixie, 1 November 2005:

> Had we done a requirements doc ten years ago . . . they might not have noticed that it would intersect their national privacy laws or business requirements, we might still have run into the NSEC3 juggernaut and be just as far off the rails now as we actually are now.

After fifteen years and millions of dollars of U.S. government grants (e.g., DISA to BIND company; NSF to UCLA; DHS to Secure64 Software Corporation),
how successful is DNSSEC?

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Surveys by DNSSEC developers, last updated 2008.10.09, have found 133 `*.com` names with DNSSEC signatures. 116 on 2008.08.20; $133 > 116$.

Why is nobody using DNSSEC?

Some of the Internet's DNS servers are extremely busy: e.g., the root servers, the `.com` servers, the `google.com` servers.

DNSSEC tries to minimize server-side costs by *precomputing* signatures of DNS records.

Signature is computed once; saved; sent to many clients. Hopefully the server can afford to sign each DNS record once.

Clients don't share the work
of *verifying* a signature.

DNSSEC tries to reduce
client-side costs through
choice of crypto primitive.

DNSSEC RFCs
say DSA is "10 to 40 times as
slow for verification" as RSA;
recommend RSA "as the
preferred algorithm" for DNSSEC;
suggest RSA key size
of only 1024 bits
for "leaf nodes in the DNS."

I say:
1024-bit RSA is irresponsible.

2003: Shamir–Tromer et al.
concluded that 1024-bit RSA
was already breakable by
large companies and botnets.

2003: RSA Laboratories
recommended a transition to
2048-bit keys "over the remainder
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But *most users don't know this*.
Why aren't they using DNSSEC?

Effects of precomputation:

1. Pain for implementors.
Hundreds of DNS tools
need to be modified to
precompute and store signatures.

2. Pain for administrators,
far beyond a simple upgrade.

3. Reduced privacy. DNSSEC
publishes all "secured" DNS
records. (NSEC3: almost all.)

4. Reduced reliability, "DNSSEC
suicide," reduced denial-of-service
protection, etc.

Rethinking signatures

What we've learned:
DNSSEC precomputes
public-key signatures for speed,
creating severe usability problems
while sacrificing security.

Can we achieve adequate speed
without precomputation?
Let's change the design.

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Can we achieve adequate speed
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Let's change the design.

1. Add encryption.
Want to protect against sabotage
and against espionage.
So use public-key signatures
and public-key encryption.

2. Merge signing with encryption.

"Public-key signcryption" protects against forgery and eavesdropping in one step.

"Public-key authenticated encryption" is even faster.

No need to
partition the algorithms into
an encryption component and
an authentication component.
Combined algorithms are faster.

3. Merge public-key operations across multiple messages.

It's silly for a sender
to authcrypt two messages
to the same recipient.

"Hybrid cryptography"
is much faster.

Example: Sender
generates a random AES key,
authcrypts the AES key,
uses the AES key to encrypt and
authenticate both messages.

4. Choose sensible primitives.

256-bit elliptic-curve cryptography using public-domain software:

489069 Core 2 cycles to handle a new communication partner.

5355 cycles to encrypt and authenticate a 510-byte message.

6786 cycles to verify and decrypt a legitimate 510-byte message.

3465 cycles to reject a forged 510-byte message.

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Handling 4 trillion partners/day:
under \$1000000.

Administration, implementation:
Much simpler than DNSSEC.
See `http://dnscurve.org`.

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just before transmission,
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Final question for today:
Can this protection
be pushed beyond DNS
to protect every Internet packet?