Toward Unspoofable Network Identifiers

CS 585
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The Problem

- DNS Spoofing Attacks (e.g., Kaminsky)
- At link (Ethernet) and IP layers, either:
  - Software sets the source address in the packet, or
  - Software can change the "hardware address"
- So: anybody can send a packet with any address
- Bottom Line: no reliable way to identify the source of a packet

NOTA BENE: Not clear this is entirely a bad thing. (Why?)

Public-Key Cryptography

- Principles
  - Public key can be known to anyone
  - Private key is known only to the principal being authenticated
  - Principal signs message via computation using message and private key
    - Computation produces a sequence of bits: the signature
    - Invariably sign hash of info instead of complete message
  - Authenticator verifies signature:
    - Requires public key, signature, and original message
    - Result of computation indicates authenticity (or not)

Public-Key Cryptography

- Issues
  - Authenticator must have a way to obtain the signer's public key
  - How can authenticator know it has the right public key?
    - Note: requiring a secure channel to the principal begs the question!
  - Attempted solution: Certification Hierarchy
    - Certificates bind a public key to a digital identifier
    - Certification Authority (CA) issues and signs each certificate
    - Authenticator must have public key of CA → recurse
    - Ultimately there must be some well-known "root" CA public keys
  - Problem: what identifier to use
    - John Smith? 207.110.44.109?

Using PKC to create “Unspoofable” IDs

- DNSSEC
  - RFC’s 4033-4035, 5155
  - Idea: bind public keys to fully-qualified domain names
- Cryptographically-Generated Addresses (CGA)
  - RFC 3972
  - Idea: use hash of public key as identifier

DNSSEC: Using PKC to Secure DNS

- Basic Idea: Secure zone has a public key
  - Stored in a DNSKEY record (a new type of RR)
  - Used to sign other records in the zone
  - Signatures are stored in RRSIG records
- Other FQDNs can also have keys (e.g., www.amazon.com)

Simple Example Zone Database without DNSSec:

cs.uky.edu	IN	SOA	
cs.uky.edu	IN	NS	ncc.uky.edu
cs.uky.edu	IN	NS	al.cs.uky.edu
cs.uky.edu	IN	A	128.163.1.6
al.cs.uky.edu	IN	A	128.163.146.100
neosho.cs.uky.edu	IN	A	128.163.146.22
cs.uky.edu	IN	SOA	

Glue records

Zone data

DNSSec: Using PKC to Secure DNS

Simplified Example Zone Database with DNSSec:

cs.uky.edu	IN	SOA	
cs.uky.edu	IN	RRSig	type covered: SOA [signature]
cs.uky.edu	IN	DNSKey	[public key]
cs.uky.edu	IN	RRSig	type covered: DNSKey [signature]
cs.uky.edu	IN	NS	ncc.uky.edu
cs.uky.edu	IN	NS	al.cs.uky.edu
cs.uky.edu	IN	RRSig	type covered: NS [signature]

⋮

neosho.cs.uky.edu	IN	A	128.163.146.22
neosho.cs.uky.edu	IN	RRSig	type covered: A [signature]
cs.uky.edu	IN	SOA	

Signed with cs.uky.edu's private key

DNSSec, cont.

- Problem: How to authenticate the statement that no record exists?
  - Solution: NSEC RR (“Next Secure”)
  - Each record in a secure zone is followed by an NSEC record, indicating the next FQDN in the zone, and what types of RRs are associated with that FQDN
  - Based on precise definition of canonical ordering of RRs
  - NSEC record asserts that “there are no records between this one and the indicated one in the canonical list

neosho.cs.uky.edu	IN	A	128.163.146.22
neosho.cs.uky.edu	IN	NSEC	nobby.cs.uky.edu

DNSSec: The Whole Picture

Simplified Example Zone Database including NSEC:

cs.uky.edu	IN	SOA	
cs.uky.edu	IN	DNSKey	[public key]
cs.uky.edu	IN	RRSig	type covered: SOA [signature]
cs.uky.edu	IN	NS	ncc.uky.edu
cs.uky.edu	IN	NS	al.cs.uky.edu
cs.uky.edu	IN	RRSig	type covered: NS [signature]
cs.uky.edu	IN	NSEC	neosho.cs.uky.edu A
cs.uky.edu	IN	RRSig	type covered: NSEC [signature]
⋮			
neosho.cs.uky.edu	IN	A	128.163.146.22
neosho.cs.uky.edu	IN	RRSig	type covered: A [signature]
neosho.cs.uky.edu	IN	NSEC	cs.uky.edu SOA
neosho.cs.uky.edu	IN	RRSig	type covered: NSEC [signature]
cs.uky.edu	IN	SOA	

Canonical Order

example

a.example

yljkjljk.a.example

Z.a.example

zABC.a.EXAMPLE

z.example

\001.z.example

*.z.example

\200.z.example

DNSSEC Issues

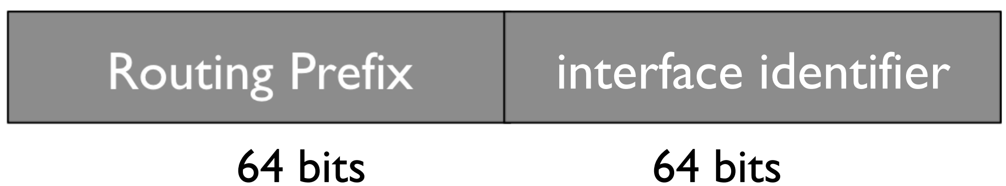
- All-or-nothing: spec (RFC 4034 & 4035) says entire zone must be secure or not
- ~Quadruples the size of the database
  - RRSig RR (x 2) plus NSEC RR for each existing RRset
  - New RR types are large (containing digital signatures)
- NSEC allows enumeration of all names in a zone
  - This is considered a bad thing (aid to intruders)
  - NSEC3 RR introduced as a fix
    - NSEC3 uses a hash chain to provide authenticated denial of existence
- Parent zones must be secure
  - MUST be sure you are talking to an authoritative nameserver for the secure zone
  - Root zone has well-known public key

Cryptographically-Generated Addresses (CGA)

- Well-known idea: if your identifier space is large enough and unstructured, you can use a hash of the public key as the identifier: *self-certifying identifiers!*
- Would like to use this to bind public keys to addresses
- Note: security of self-certifying IDs rests on properties of hash functions
  - Viz: infeasible to find a collision
- Problem: addresses are neither unstructured nor large enough

Cryptographically Generated Addresses

- IPv6 only
- Concept: use (part of) the hash of the public key for the interface identifier of the IPv6 address

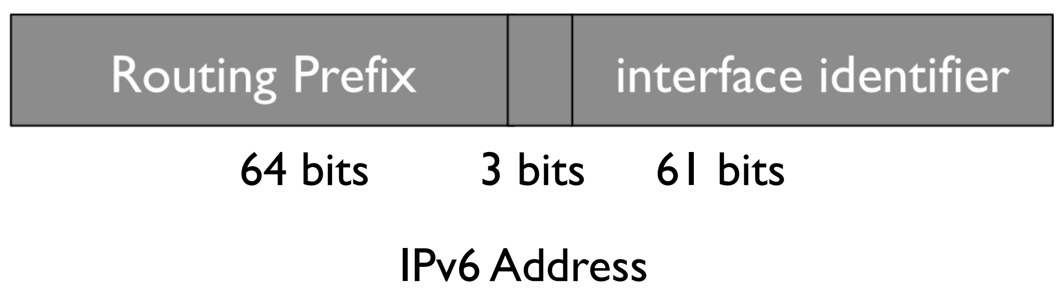


IPv6 Address

- Problem: 64 bits is not enough to be secure

Cryptographically Generated Addresses

- Solution: Require that some number of the high-order bits of the hash of the public key be 0
  - How many is determined by the security parameter, which is part of the address



- Computation: choose a random 128-bit string; compute SHA-1 hash of it. If the high-order (7 x sec value) bits are zero, do another hash to create the interface ID

Self-certifying IPv6 Addresses

- Advantages:
  - Completely distributed address assignment
  - No PKI required
- Disadvantages:
  - To authenticate an IPv6 datagram, sender must include:
    - Public key
    - Signature on (hash of) the contents of the datagram
  - Heavy computational burden in creation of interface ID
    - Work grows exponentially with security parameter
    - Find a hash value with 16, 32, or more leading zeros