Lecture 27
November 29, 2021

Trust

- Goal of certificate: bind correct identity to DN
- Question: what is degree of assurance?
- X.509v4, certificate hierarchy
  - Depends on policy of CA issuing certificate
  - Depends on how well CA follows that policy
  - Depends on how easy the required authentication can be spoofed
- Really, estimate based on the above factors

Example: Passport Required

- DN has name on passport, number and issuer of passport
- What are points of trust?
  - Passport not forged and name on it not altered
  - Passport issued to person named in passport
  - Person presenting passport is person to whom it was issued
  - CA has checked passport and individual using passport

PGP Certificates

- Level of trust in signature field
- Four levels
  - Generic (no trust assertions made)
  - Persona (no verification)
  - Casual (some verification)
  - Positive (substantial verification)
- What do these mean?
  - Meaning not given by OpenPGP standard
  - Signer determines what level to use
  - Casual to one signer may be positive to another

Identity on the Web

- Host identity
  - Static identifiers: do not change over time
  - Dynamic identifiers: changes as a result of an event or the passing of time
- State and Cookies
- Anonymity
  - Anonymous email
  - Anonymity: good or bad?

Host Identity

- Bound up to networking
  - Not connected: pick any name
  - Connected: one or more names depending on interfaces, network structure, context
- *Name* identifies principal
- *Address* identifies location of principal
  - May be virtual location (network segment) as opposed to physical location (room 222)

Example

- Layered network
  - MAC layer
    - Ethernet address: 00:05:02:6B:A8:21
    - AppleTalk address: network 51, node 235
  - Network layer
    - IP address: 192.168.35.89
  - Transport layer
    - Host name: cherry.orchard.chekhov.ru

Danger!

- Attacker spoofs identity of another host
  - Protocols at, above the identity being spoofed will fail
  - They rely on spoofed, and hence faulty, information
- Example: spoof IP address, mapping between host names and IP addresses

Domain Name Server

- Maps transport identifiers (host names) to network identifiers (host addresses)
  - Forward records: host names → IP addresses
  - Reverse records: IP addresses → host names
- Weak authentication
  - Not cryptographically based
  - Various techniques used, such as reverse domain name lookup

Reverse Domain Name Lookup

- Validate identity of peer (host) name
  - Get IP address of peer
  - Get associated host name via DNS
  - Get IP addresses associated with host name from DNS
  - If first IP address in this set, accept name as correct; otherwise, reject as spoofed
- If DNS corrupted, this won't work

Floating (Dynamic) Identifiers

- Assigned to principals for a limited time
  - Server maintains pool of identifiers
  - Client contacts server using *local identifier*
    - Only client, server need to know this identifier
  - Server sends client *global identifier*
    - Client uses global identifier in other contexts, for example to talk to other hosts
    - Server notifies intermediate hosts of new client, global identifier association

Example: DHCP

- DHCP server has pool of IP addresses
- Laptop sends DHCP server its MAC address, requests IP address
  - MAC address is local identifier
  - IP address is global identifier
- DHCP server sends unused IP address
  - Also notifies infrastructure systems of the association between laptop and IP address
- Laptop accepts IP address, uses that to communicate with hosts other than server

Example: Gateways

- Laptop wants to access host on another network
  - Laptop’s address is 10.1.3.241
- Gateway assigns legitimate address to internal address
  - Say IP address is 101.43.21.241
  - Gateway rewrites all outgoing, incoming packets appropriately
  - Invisible to both laptop, remote peer
- Internet protocol NAT works this way

Weak Authentication

- Static: host/name binding fixed
- Dynamic: host/name binding varies over time
  - Must update reverse records in DNS
    - Otherwise, the reverse lookup technique fails
  - Cannot rely on binding remaining fixed unless you know the period of time over which the binding persists

DNS Security Issues

- Trust is that name/IP address binding is correct
- Goal of attacker: associate incorrectly an IP address with a host name
  - Assume attacker controls name server, or can intercept queries and send responses

Attacks

- Change records on server
- Add extra record to response, giving incorrect name/IP address association
  - Called "cache poisoning"
- Attacker sends victim request that must be resolved by asking attacker
  - Attacker responds with answer plus two records for address spoofing (1 forward, 1 reverse)
  - Called "ask me"

DNS Security Extensions (DNSSEC)

- DNS organizes information into *resource records* (RRs)
  - CNAME RR: canonical name for host
- DNSSEC adds some RRs for cryptographic authentication of record
  - RRSIG RR: signature
    - These associate digital signature with sets of records in DNS
  - DNSKEY RR: public key associated with DNS server
    - Resolver uses this to verify signature sent with DNS records
- Resolver requests record corresponding to host name
  - Server responds with NSEC RR showing *next* valid host name in sorted order
  - NSEC RR: next host name (the one following the host these RRs refer to)
    - Tells querying host that queried-for host does not exist in that domain

NSEC RR Problem and Solution

- Attack: derive all host names in domain by sending queries for host names that have no corresponding addresses
- Solution: NSEC3 RR is like NSEC RR, but host name replaced by cryptographic hash of host name
  - Now attacker cannot get the host names of all systems in the domain
- DNSSEC benefits:
  - Spoofing, cache poisoning immediately detectable
  - Minimizes overhead of doing so
    - No associated PKI defined
    - No key revocation mechanism defined (but can just change DNS server's public, private keys)

Cookies

- Token containing information about state of transaction on network
  - Usual use: refers to state of interaction between web browser, client
  - Idea is to minimize storage requirements of servers, and put information on clients
- Client sends cookies to server

Some Fields in Cookies

- *name*, *value*: *name* has given *value*
- *expires*: how long cookie valid
  - Expired cookies discarded, not sent to server
  - If omitted, cookie deleted at end of session
- *domain*: domain for which cookie intended
  - Consists of last *n* fields of domain name of server
  - *Must* have at least one "." in it
- *secure*: send only over secured (TLS, HTTPS) connection

Example

- Caroline puts 2 books in shopping cartcart at books.com
  - Cookie: *name* bought, *value* BK=234&BK=8753, *domain* .books.com
- Caroline looks at other books, but decides to buy only those
  - She goes to the purchase page to order them
- Server requests cookie, gets above
  - From cookie, determines books in shopping cart

Who Can Get the Cookies?

- Web browser can send *any* cookie to a web server
  - Even if the cookie's domain does not match that of the web server
  - Usually controlled by browser settings
- Web server can *only* request cookies for its domain
  - Cookies need not have been sent by that browser

Where Did the Visitor Go?

- Server books.com sends Caroline 2 cookies
  - First described earlier
  - Second has *name* “id”, *value* “books.com”, *domain* “adv.com”
- Advertisements at books.com include some from site adv.com
  - When drawing page, Caroline’s browser requests content for ads from server “adv.com”
  - Server requests cookies from Caroline’s browser
  - By looking at *value*, server can tell Caroline visited “books.com”

Anonymity on the Web

- Recipients can determine origin of incoming packet
  - Sometimes not desirable
- Anonymizer: a site that hides origins of connections
  - Usually a proxy server
    - User connects to anonymizer, tells it destination
    - Anonymizer makes connection, sends traffic in both directions
  - Destination host sees only anonymizer

Example: *anon.penet.fi*

Offered anonymous email service

- Sender sends letter to it, naming another destination
- Anonymizer strips headers, forwards message
  - Assigns an ID (say, 1234) to sender, records real sender and ID in database
  - Letter delivered as if from anon1234@anon.penet.fi
- Recipient replies to that address
  - Anonymizer strips headers, forwards message as indicated by database entry

Problem

- Anonymizer knows who sender, recipient *really* are
- Called *pseudo-anonymous remailer* or *pseudonymous remailer*
  - Keeps mappings of anonymous identities and associated identities
- If you can get the mappings, you can figure out who sent what

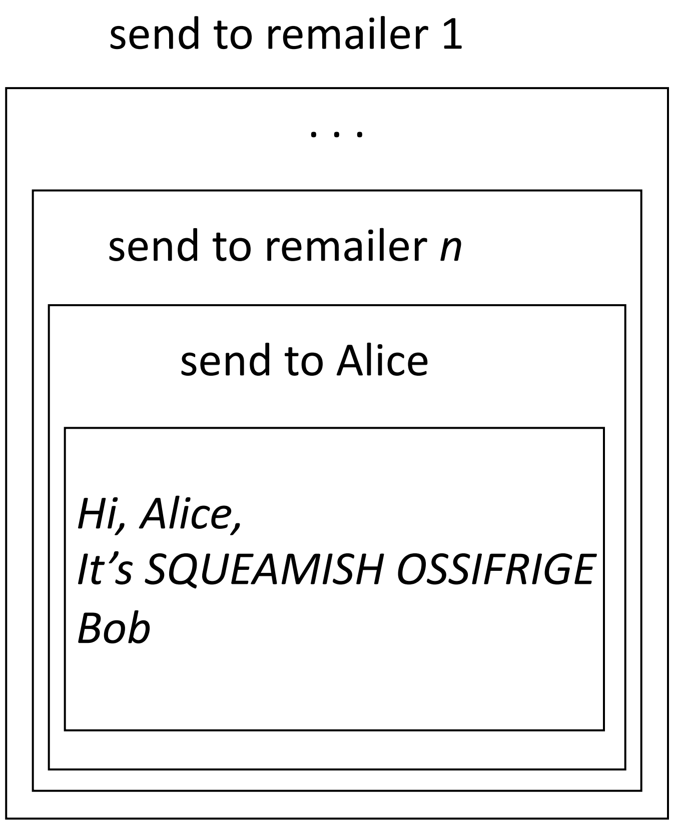
More *anon.penet.fi*

- Material claimed to be copyrighted sent through site
- Finnish court directed owner to reveal mapping so plaintiffs could determine sender
- Owner appealed, lost, subsequently shut down site

Cypherpunk Remailer

- Remailer that deletes header of incoming message, forwards body to destination
- Also called *Type I Remailer*
- No record kept of association between sender address, remailer's user name
  - Prevents tracing, as happened with *anon.penet.fi*
- Usually used in a chain, to obfuscate trail
  - For privacy, body of message may be enciphered

Cypherpunk Remailer Message



- Encipher message
- Add recipient address
- Encipher and add remailer *n*'s address
- . . .
- Encipher and add remailer 1's address
- Send this to remailer 1

Weaknesses

- Attacker monitoring entire network
  - Observes in, out flows of remailers
  - Goal is to associate incoming, outgoing messages
- If messages are cleartext, trivial
  - So assume all messages enciphered
- So use traffic analysis!
  - Used to determine information based simply on movement of messages (traffic) around the network

Attacks

- If remailer forwards message before next message arrives, attacker can match them up
  - Hold messages for some period of time, greater than the message interarrival time
  - Randomize order of sending messages, waiting until at least *n* messages are ready to be forwarded
    - Note: attacker can force this by sending *n*–1 messages into queue

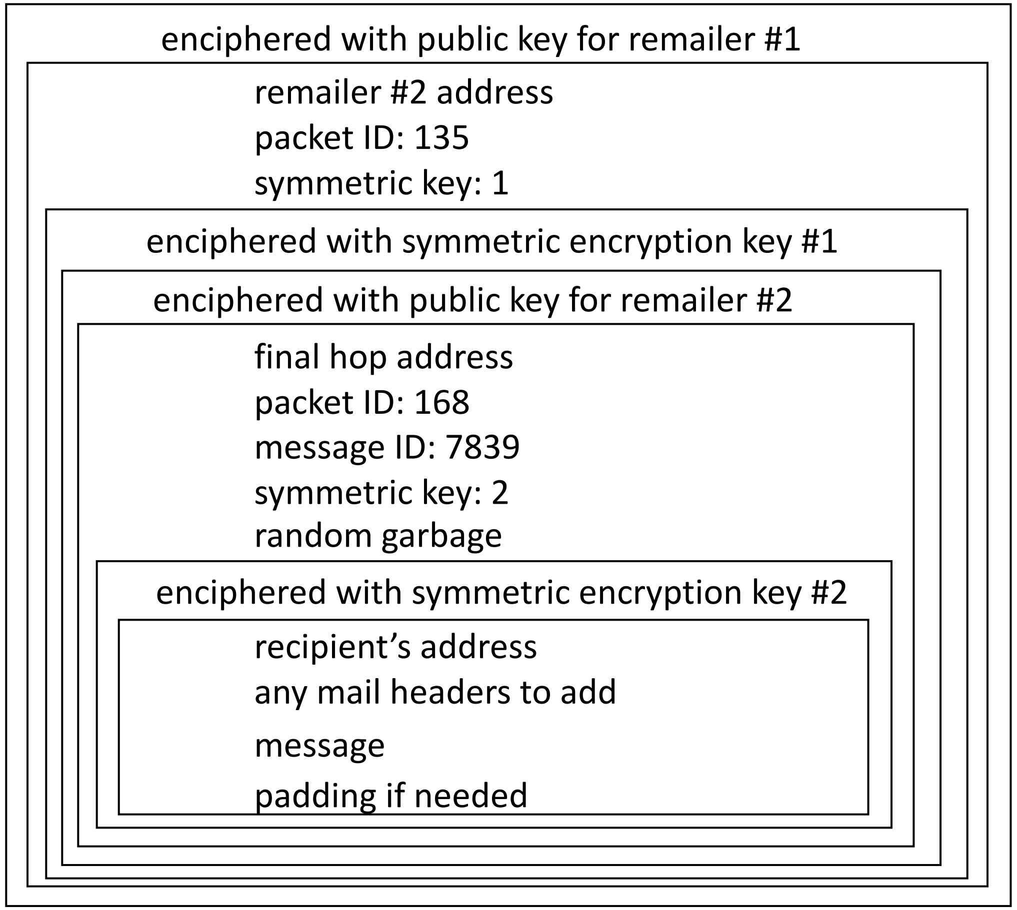
Attacks

- As messages forwarded, headers stripped so message size decreases
  - Pad message with garbage at each step, instructing next remailer to discard it
- Replay message, watch for spikes in outgoing traffic
  - Remailer can't forward same message more than once

Mixmaster (Cypherpunk Type 2) Remailer

- Cypherpunk remailer that handles only enciphered mail and pads (or fragments) messages to fixed size before sending them
  - Also called Type 2 Remailer
  - Designed to hinder attacks on Cypherpunk remailers
    - Messages uniquely numbered
    - Fragments reassembled *only* at last remailer for sending to recipient

Cypherpunk Remailer Message



Onion Routine

- Method of routing so each node in the route knows only the previous and following node
  - Typically, first node selects the route
  - Intermediate node may be able to change rest of route
- Each intermediate node has public, private key pair
  - Public key available to all nodes and any proxies
- Client, server have proxies to handle onion routing

Heart of the Onion Route

{ *expires* || *nexthop* || E_F || k_F || E_B || k_B || *payload* } pub_r

- *payload*: data associated with message
- *expires*: expiration time for which *payload* is to be saved
- *nexthop*: node to forward message to
- pub_r: public key of next hop (node)
- E_F, k_F : encryption algorithm, key to be used when sending message forward to server
- E_B, k_B : encryption algorithm, key to be used when sending message backwards to client

Notes About the Heart

- *payload* may itself be a message of this form or the data being sent
- Each router has table storing:
  - Virtual circuit number associated with a route
  - E_F, k_F, E_B, k_B for the next, previous nodes on the route
  - Next router to which messages using this route are to be forwarded
    - If last router on route, this is NULL (as is *nexthop* in the packet)

Creating a Route

- Client’s proxy determines route for the message
  - Can be defined exactly, or loosely, where the intermediate routers can route messages to next hop over other routes
- Create onion encapsulating route, put it in a *create* message and add virtual circuit number
- Forward to next (second) router on path
- That router deciphers the onion using its private key (“peeling the onion”)
  - Compare it to what’s in table; if replay, discard