Certificates

- A ubiquitous form of authentication
- Generally used with public key cryptography
- A signed electronic document proving you are who you claim to be
- Often used to help distribute other keys

Public Key Certificates

- The most common kind of certificate
- Addresses the biggest challenge in widespread use of public keys
  - How do I know whose key it is?
- Essentially, a copy of your public key signed by a trusted authority
- Presentation of the certificate alone serves as authentication of your public key

Implementation of Public Key Certificates

- Set up a universally trusted authority
- Every user presents his public key to the authority
- The authority returns a certificate
  - Containing the user's public key signed by the authority's private key
- In essence, a special type of key server

Checking a Certificate

- Every user keeps a copy of the authority's public key
- When a new user wants to talk to you, he gives you his certificate
- Decrypt the certificate using the authority's public key
- You now have an authenticated public key for the new user
- Authority need not be checked on-line

Scaling Issues of Certificates

- If there are 1-2 billion Internet users needing certificates, can one authority serve them all?
- Probably not
- So you need multiple authorities
- Does that mean everyone needs to store the public keys of all authorities?

Certification Hierarchies

- Arrange certification authorities hierarchically
- Single authority at the top produces certificates for the next layer down
- And so on, recursively

Using Certificates From Hierarchies

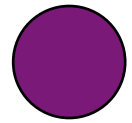
- I get a new certificate
- I don’t know the signing authority
- But the certificate also contains that authority’s certificate
- Perhaps I know the authority who signed this authority’s certificate

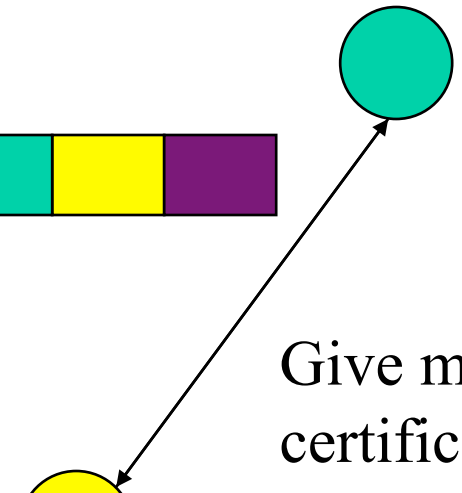
Extracting the Authentication

- Using the public key of the higher level authority,
  - Extract the public key of the signing authority from the certificate
- Now I know his public key, and it's authenticated
- I can now extract the user's key and authenticate it

A Example

Alice gets a message with a certificate





Then she uses
to check

Give me a certificate saying that I'm

Should Alice believe that he's really ?

So she uses
to check

Alice has never heard of
But she has heard of

How can
prove who he is?

Certification Hierarchies Reality

- Not really what's used
  - For the most part
- Instead, we rely on large numbers of independent certifying authorities
  - Exception is that each of them may have internal hierarchy
- Essentially, a big list
- Is this really better?

Certificates and Trust

- Ultimately, the point of a certificate is to determine if something is trusted
  - Do I trust the request enough to perform some financial transaction?
- So, Trustysign.com signed this certificate
- How much confidence should I have in the certificate?

Potential Problems in the Certification Process

- What measures did Trustysign.com use before issuing the certificate?
- Is the certificate itself still valid?
- Is Trustysign.com's signature/ certificate still valid?
- Who is trustworthy enough to be at the top of the hierarchy?

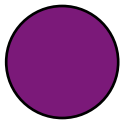
Trustworthiness of Certificate Authority

- How did Trustysign.com issue the certificate?
- Did it get an in-person sworn affidavit from the certificate's owner?
- Did it phone up the owner to verify it was him?
- Did it just accept the word of the requestor that he was who he claimed to be?
- Has authority been compromised?

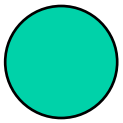
What Does a Certificate Really Tell Me?

- That the certificate authority (CA) tied a public/private key pair to identification information
- Generally doesn't tell me why the CA thought the binding was proper
- I may have different standards than that CA

Showing a Problem Using the Example

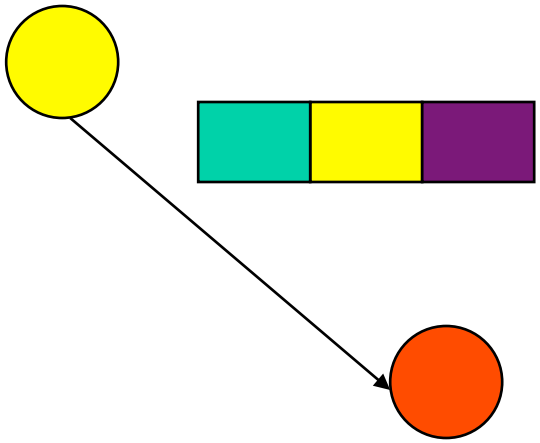


Alice likes how verifies identity



What if uses 's lax policies to pretend to be ?

But is she equally happy with how verifies identity?



Does she even know how verifies identity?

Another Big Problem

- Things change
  - E.g., 2012 compromise of Adobe private keys
- One result of change is that what used to be safe or trusted isn't any more
- If there is trust-related information out in the network, what will happen when things change?

Revocation

- A general problem for keys, certificates, access control lists, etc.
- How does the system revoke something related to trust?
- In a network environment
- Safely, efficiently, etc.
- Related to revocation problem for capabilities

Revisiting Our Example

Someone discovers that ■ has obtained a false certificate for ■

How does Alice make sure that she's not accepting ■'s false certificate?

Realities of Certificates

- Most OSes come with set of "pre-trusted" certificate authorities
- System automatically processes (i.e., trusts) certificates they sign
- Usually no hierarchy
- If not signed by one of these, present it to the user
  - Who always accepts it . . .

An Example

- Firefox web browser
- Makes extensive use of certificates to validate entities
  - As do all web browsers
- Comes preconfigured with several certificate authorities
  - Over 200 of them

Firefox Preconfigured Certificate Authorities

- Some you'd expect:
  - Microsoft, RSA Security, Verisign, etc.
- Some you've probably never heard of:
  - Unizeto Sp. z.o.o., Netlock Halozatbiztonsagi Kft.,Chungwa Telecom Co. Ltd.

The Upshot

- If Netlock Halozatbiztonsagi Kft. says someone's OK, I trust them
  - I've never heard of Netlock Halozatbiztonsagi Kft.
  - I have no reason to trust Netlock Halozatbiztonsagi Kft.
  - But my system's security depends on them

The Problem in the Real World

- In 2011, a Dutch authority (DigiNotar) was compromised
- Attackers generated lots of bogus certificates signed by DigiNotar
  - "Properly" signed by that authority
  - For popular web sites
- Until compromise discovered, everyone trusted them

Effects of DigiNotar Compromise

- Attackers could transparently redirect users to fake sites
  - What looked like Twitter was actually attacker's copycat site
- Allowed attackers to eavesdrop without any hint to users
- Apparently used by authorities in Iran to eavesdrop on dissidents

How Did the Compromise Occur?

- DigiNotar had crappy security
  - Out-of date antivirus software
  - Poor software patching
  - Weak passwords
  - No auditing of logs
  - Poorly designed local network
- A company providing security services paid little attention to security

But how were you supposed to know that?

Another Practicality

- Certificates have expiration dates
  - Important for security
  - Otherwise, long-gone entities would still be trusted
- But perfectly good certificates also expire
  - Then what?

The Reality of Expired Certificates

- When I hear my server's certificate has expired, what do I do?
  - I trust it anyway
  - After all, it's my server
- But pretty much everyone does that
  - For pretty much every certificate
- Not so secure

The Core Problem With Certificates

- Anyone can create some certificate
- Typical users have no good basis for determining whose certificates to trust
  - They don't even really understand what they mean
- Therefore, they trust almost any certificate

Should We Worry About Certificate Validity?

- Starting to be a problem
  - Stuxnet is one example
  - Compromise of DigiNotar and Adobe also
  - Increasing incidence of improper issuance, like Verisign handing out Microsoft certificates
- Not the way most attackers break in today
- With all their problems, still not the weakest link
  - But now being exploited, mostly by most sophisticated adversaries