INF3510 Information Security
University of Oslo
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Lecture 6

Key Management and PKI

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Key Management

- The security of cryptographically protected information depends on:
  - The size of the keys
  - The robustness of cryptographic algorithms/protocols
  - <u>The protection and management afforded to the keys</u>
- Key management provides the foundation for the secure generation, storage, distribution, and destruction of keys.
- Proper key management is essential to the robust use of cryptography for security.
- Poor key management may easily compromise strong algorithms.

Key Usage

- A single key should be used for **only** one purpose
  - e.g., encryption, authentication, key wrapping, random number generation, or digital signatures
- Using the same key for two different processes may weaken the security of one or both of the processes.
- Limiting the use of a key limits the damage that could be done if the key is compromised.
- Some uses of keys interfere with each other
  - e.g. an asymmetric key pair should only be used for either encryption or digital signatures, not both.

Types of Cryptographic Keys

- How many types of keys are there?
- They’re classified according to:
  - Whether they’re public, private or symmetric
  - Their use
  - For asymmetric keys, also whether they’re static or ephemeral
- NIST Special Publication 800-57, Recommendation for Key Management – Part 1: General, August 2005, defines **19** types of cryptographic keys.

Crypto Period

- The crypto period is the time span during which a specific key is authorized for use
- The crypto period is important because it:
  - Limits the amount of information protected by a given key that is available for cryptanalysis.
  - Limits the amount of exposure if a single key is compromised.
  - Limits the use of a particular algorithm to its estimated effective lifetime.

Factors Affecting Crypto Periods

- In general, as the sensitivity of the information or the criticality of the processes increase, the length of the cryptoperiods should **decrease** in order to limit the damage that might result from each compromise.
- Short cryptoperiods may be counter productive, particularly where denial of service is the paramount concern, and there is a significant overhead and potential for error in the re-keying, key update or key derivation process.
- The cryptoperiod is therefore a trade-off

Key Usage Periods

- A key is used for both <u>protecting</u> and <u>processing</u>.
  - in the protection period, the key is e.g. used for encryption.
  - In the processing period, the key is e,g. used for decryption
- A symmetric key **shall not** be used to provide protection **after** the end of the protection period.
- The processing period normally extends beyond the protection period.
- The cryptoperiod of a symmetric key is the period from the beginning of the protection period to the end of the processing period.

Recommended Crypto Periods

Ref: NIST SP 800-57

Key Type	Cryptoperiod	
	Protection Period	Usage Period
1. Private Signature Key	1-3 years	
2. Public Signature Key	Several years (depends on key size)	
3. Symmetric Authentication Key	<= 2 years	<= OUP + 3 years
4. Private Authentication Key	1-2 years	
5. Public Authentication Key	1-2 years	
6. Symmetric Data Encryption Keys	<= 2 years	<= OUP + 3 years
7. Symmetric Key Wrapping Key	<= 2 years	<= OUP + 3 years

Recommended Crypto Periods (cont.)

Ref: NIST SP 800-57

Key Type	Cryptoperiod	
	Protection Period	Usage Period
8. Symmetric and asymmetric RNG Keys	Upon reseeding	
9. Symmetric Master Key	About 1 year	
10. Private Key Transport Key	<= 2 years	
11. Public Key Transport Key	1-2 years	
12. Symmetric Key Agreement Key	1-2 years	
13. Private Static Key Agreement Key	1-2 years	

Recommended Crypto Periods (cont.)

Ref: NIST SP 800-57

Key Type	Cryptoperiod	
	Protection Period	Usage Period
14. Public Static Key Agreement Key	1-2 years	
15. Private Ephemeral Key Agreement Key	One key agreement transaction	
16. Public Ephemeral Key Agreement Key	One key agreement transaction	
17. Symmetric Authorization (Access Approval) Key	<= 2 years	
18. Private Authorization (Access Approval) Key	<= 2 years	
19. Public Authorization (Access Approval) Key	<= 2 years	

Key Generation

- Most sensitive of all cryptographic functions.
- Need to prevent unauthorized disclosure, insertion, and deletion of keys.
- Automated devices that generate keys and initialisation vectors (IVs) should be physically protected to prevent:
  - disclosure, modification, and replacement of keys,
  - modification or replacement of IVs.
- Keys should be randomly chosen from full range of key space.

Random Number Generator Seeds

- RNG keys are used to initialise the generation of random symmetric/asymmetric keys
- Knowing the seed may determine the key uniquely
- Requires confidentiality and integrity protection
  - Period of protection for seeds, e.g.:
    a. Used once and destroyed
    b. From generation until no longer needed for subsequent reseeding
    c. Shall be destroyed at the end of the protection period

Key Generation Examples

- Stream cipher keys
  - Long true random key stream (One-Time Pad), or
  - Short random key (e.g. 128 bits) input to keystream generator to generate pseudorandom key stream
- AES symmetric block cipher keys
  - Select adequate key length, 128, 192 or 256 bits
  - Ensure that any key is as probable as any other
- RSA asymmetric cipher
  - Make sure n = p·q (modulus) is sufficiently large to prevent factoring, e.g. n= 2048 bit
  - Randomness in seeds to generate primes p and q must by twice the security required. If e.g. 128 bit security is required then use 256 bit randomness

Compromise of keys and keying material

- Key compromise occurs when the protective mechanisms for the key fail, and the key can no longer be trusted
- When a key is compromised, all use of the key to protect information **shall** cease and the compromised key **shall** be revoked.
  - However, the continued use of the key under controlled circumstances to remove or verify the protections may be warranted, depending on the risks of continued use and an organization's Key Management Policy.
- The continued use of a compromised key **shall** be limited to <u>processing</u> protected information.
  - In this case, the entity that uses the information **shall** be made fully aware of the dangers involved.

Key Compromise Recovery Plan

- A compromise recovery plan **should** contain:
  - The identification of the personnel to notify.
  - The identification of the personnel to perform the recovery actions.
  - The re-key method.
  - Any other recovery procedures, such as:
    - Physical inspection of equipment.
    - Identification of all information that may be compromised.
    - Identification of all signatures that may be invalid due to the compromise of a signing key.
    - Distribution of new keying material, if required.

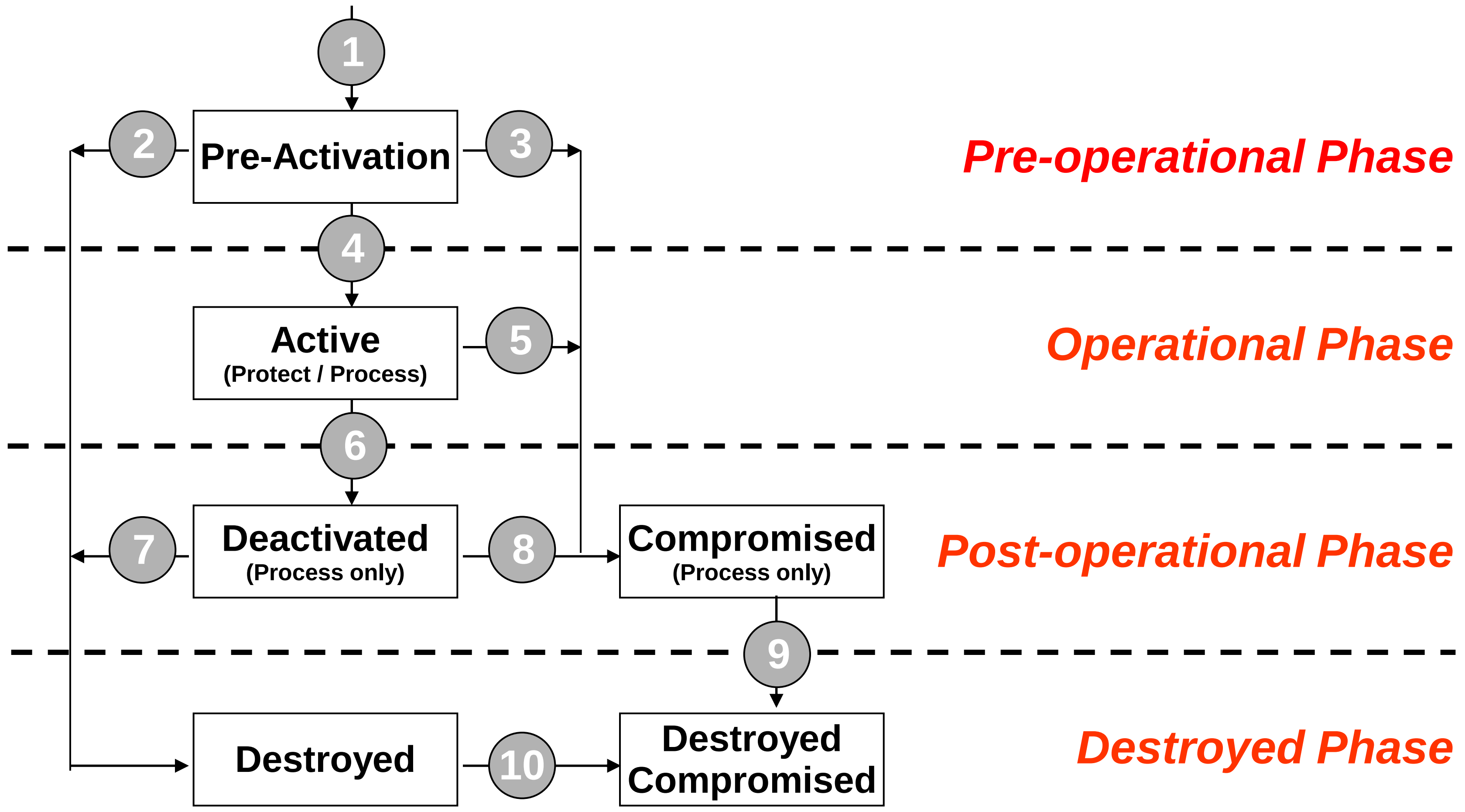
Undetected Key Compromise

- The worst form of key compromise is when it is not detected.
- Nevertheless certain protective measures can be taken. Key management systems (KMS) **should** be designed:
  - to mitigate the negative effects of a key compromise.
  - so that the compromise of a single key has limited consequences, e.g., a single key could be used to protect only a single user or a limited number of users, rather than a large number of users.
- Often, systems have alternative methods to authenticate communicating entities that do not rely solely on the possession of keys.
  - Avoid building a system with catastrophic weaknesses.

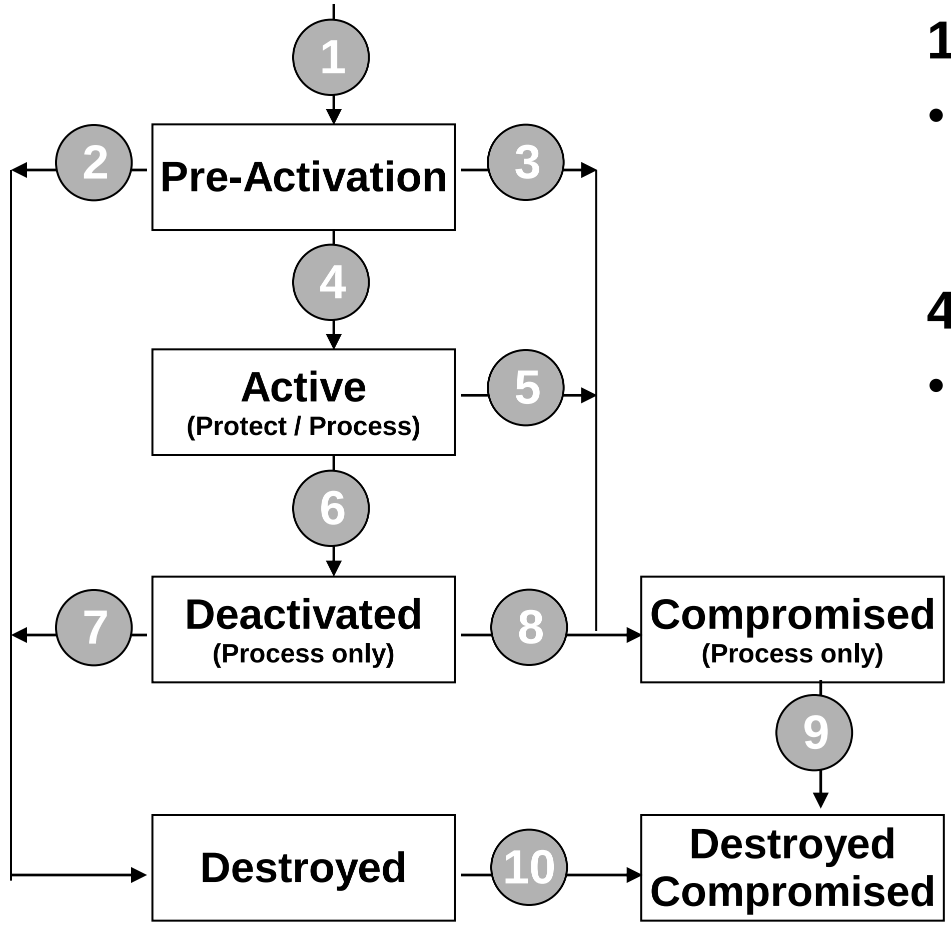
Key destruction

- No key material should reside in volatile memory or on permanent storage media after destruction
- Key destruction methods, e.g.
  - Simple delete operation on computer
    - may leave undeleted key e.g. in recycle bin or on disk sectors
  - Special delete operation on computer
    - that leaves no residual data, e.g. by overwriting
  - Magnetic media degaussing
  - Destruction of physical device e.g high temperature
  - Master key destruction which logically destructs subordinate keys

Key States, Transitions and Phases
Ref: NIST SP 800-57



Key States and Transitions
Ref: NIST SP 800-57



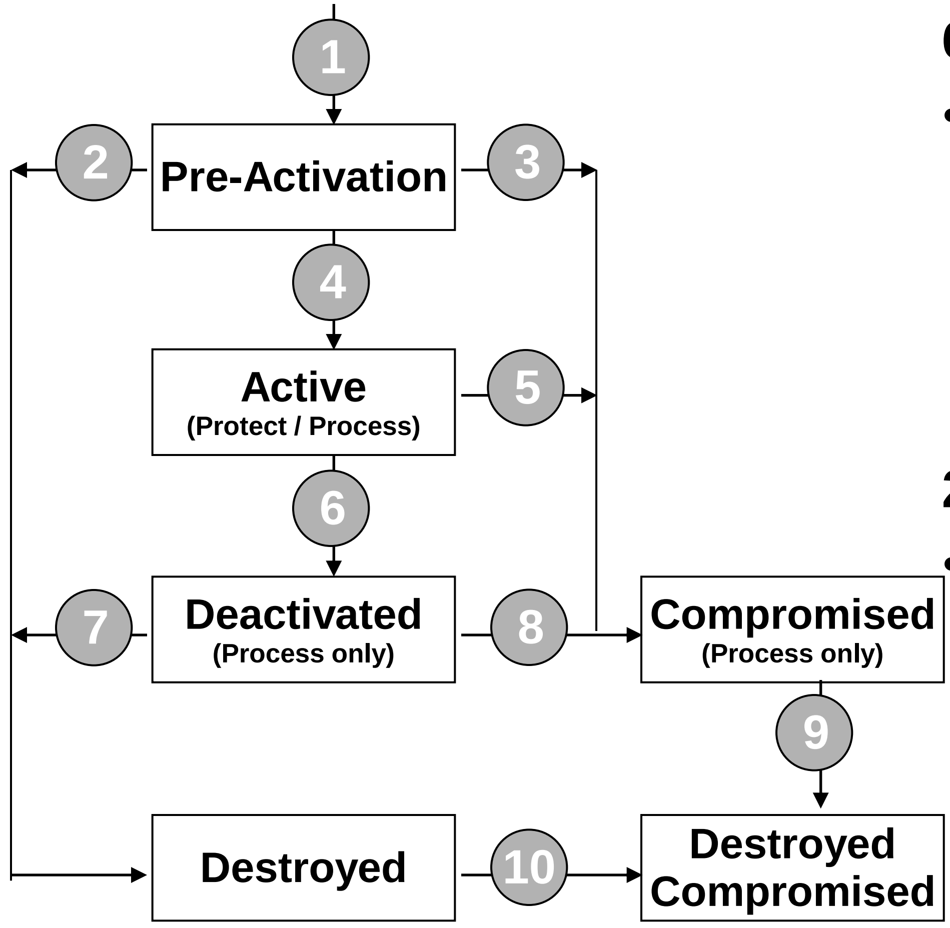
1) Pre-Activation

- The key material has been generated but is not yet authorized for use

4) Active

- The key may be used to cryptographically protect information or cryptographically process previously protected information, or both. When a key is active, it may be designated to protect only, process only, or both.

Key States and Transitions (cont.)
Ref: NIST SP 800-57



6) Deactivated

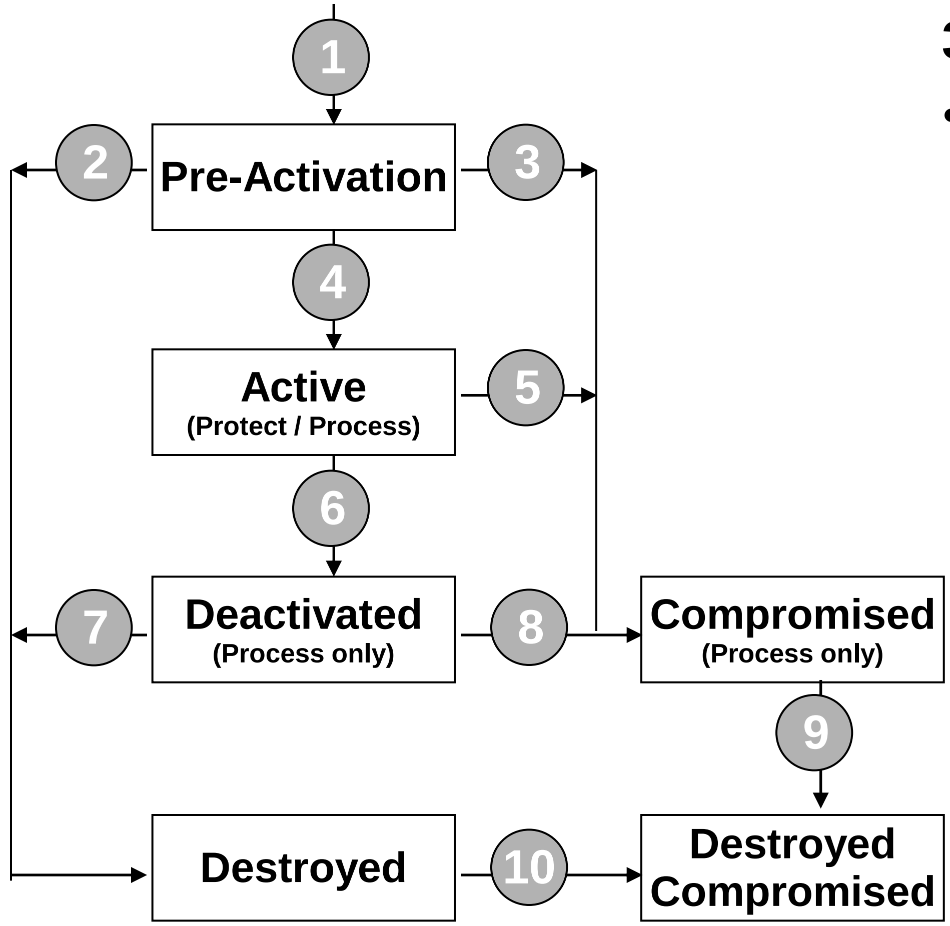
- A key whose cryptoperiod has expired but is still needed to perform cryptographic processing, gets deactivated until it is destroyed.

2), 7) Destroyed

- The key has been destroyed. Even though the key no longer exists in this state, certain key attributes (e.g. key name, type and cryptoperiod) may be retained.

Key States and Transitions (cont.)

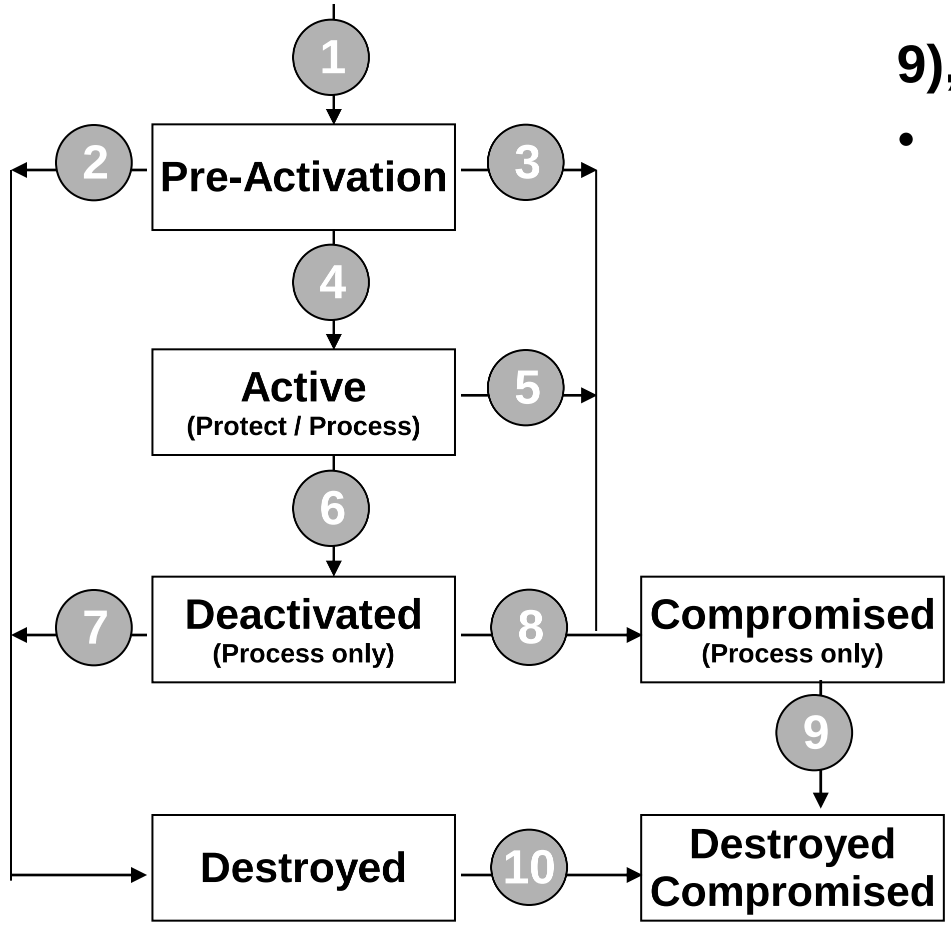
Ref: NIST SP 800-57



3), 5), 8) Compromised

- Generally, keys are compromised when they are released to or determined by an unauthorized entity. If the integrity or secrecy of the key is suspect, it is revoked. The key is not used to apply protection to information. In some cases, the key may be used for processing.

Key States and Transitions (cont.)
Ref: NIST SP 800-57



9), 10) Destroyed Compromised

- The key is destroyed after a compromise, or the key is destroyed and a compromise is later discovered. Key attributes may be retained.

Key Protection

- Keys should be
  - accessible for authorised users,
  - protected from unauthorised users
- Old keys must be kept, if messages encrypted under these keys are stored
  - Where will they be kept?
  - How will they be kept securely?
  - Who will know how to access them when required?

Key Protection Examples

- Symmetric ciphers
  - Never stored or transmitted ‘in the clear’
  - May use hierarchy: session keys encrypted with master
  - Master key protection:
    - Locks and guards
    - Tamper proof devices
    - Passwords/passphrases
    - Biometrics
- Asymmetric ciphers
  - Private keys need confidentiality protection
  - Public keys need integrity/authenticity protection

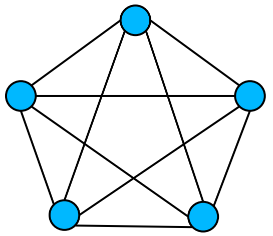
Why the interest in PKI ?

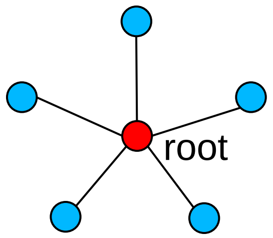
Cryptography solves security problems in open networks,
… but creates key management complexity.

Public-key cryptography simplifies the key management,
… but creates trust management problems.

Key distribution: The problem

- Domain of n nodes
- Every pair of nodes need to communicate securely using cryptography
- How many secure key distributions needed ?
  - Symmetric keys: $n(n\text{-}1)/2$ secret keys
    - confidentiality and authenticity required
    - too difficult
  - Asymmetric keys: $n(n\text{-}1)/2$ public keys
    - authenticity of public keys required
    - too difficult
  - Asymmetric with PKI: 1 root public key to n parties
    - authenticity of root public key required
    - … more difficult than you might think





Session key establishment

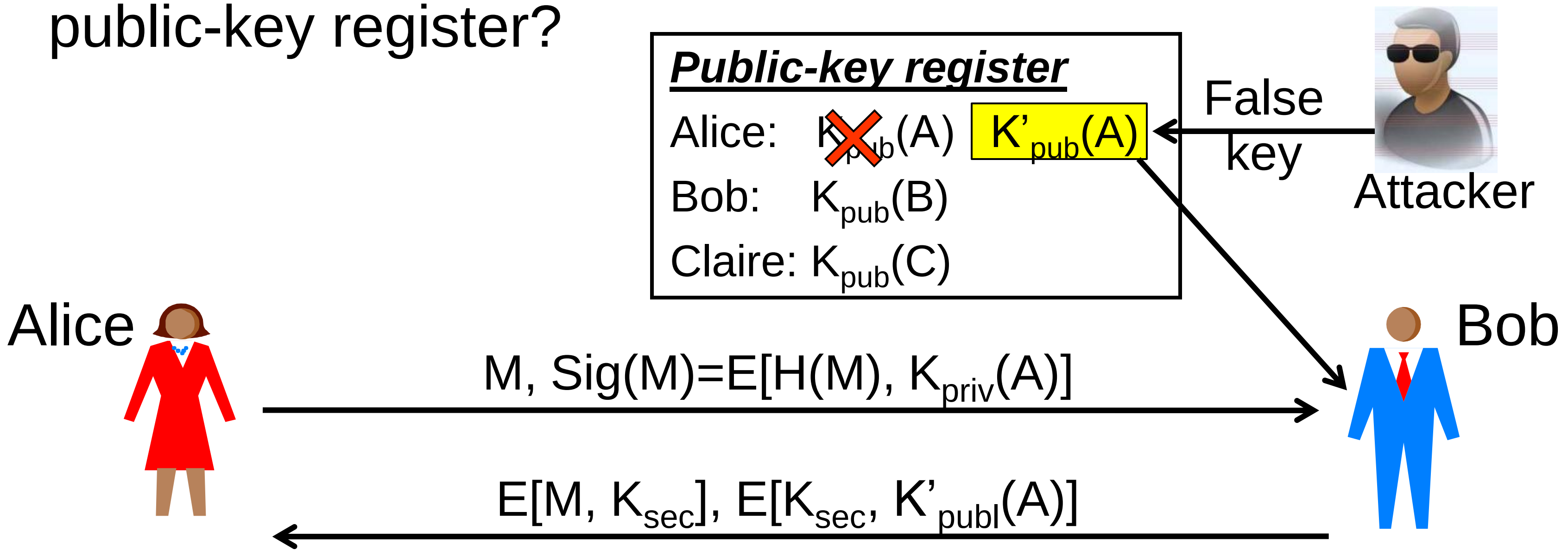
- Symmetric ciphers are more efficient than asymmetric.
  - typically used for secure data communication sessions.
- Session keys for symmetric ciphers must be distributed under the protection of permanent keys.

Three options for protecting the distribution of session keys

1. Use existing shared secret keys
   - Does not scale to large groups or open networks
2. Use a trusted third party (server) who shares a symmetric (long-term) key with each user
   - Need protocol such as Kerberos (lecture on authent.)
3. Use asymmetric cipher to protect session key
   - Requires PKI (see next)

Public keys and the spoofing problem

- Assume that public keys are stored in public register
- Consequence of attacker inserting false key for Alice in the public-key register?



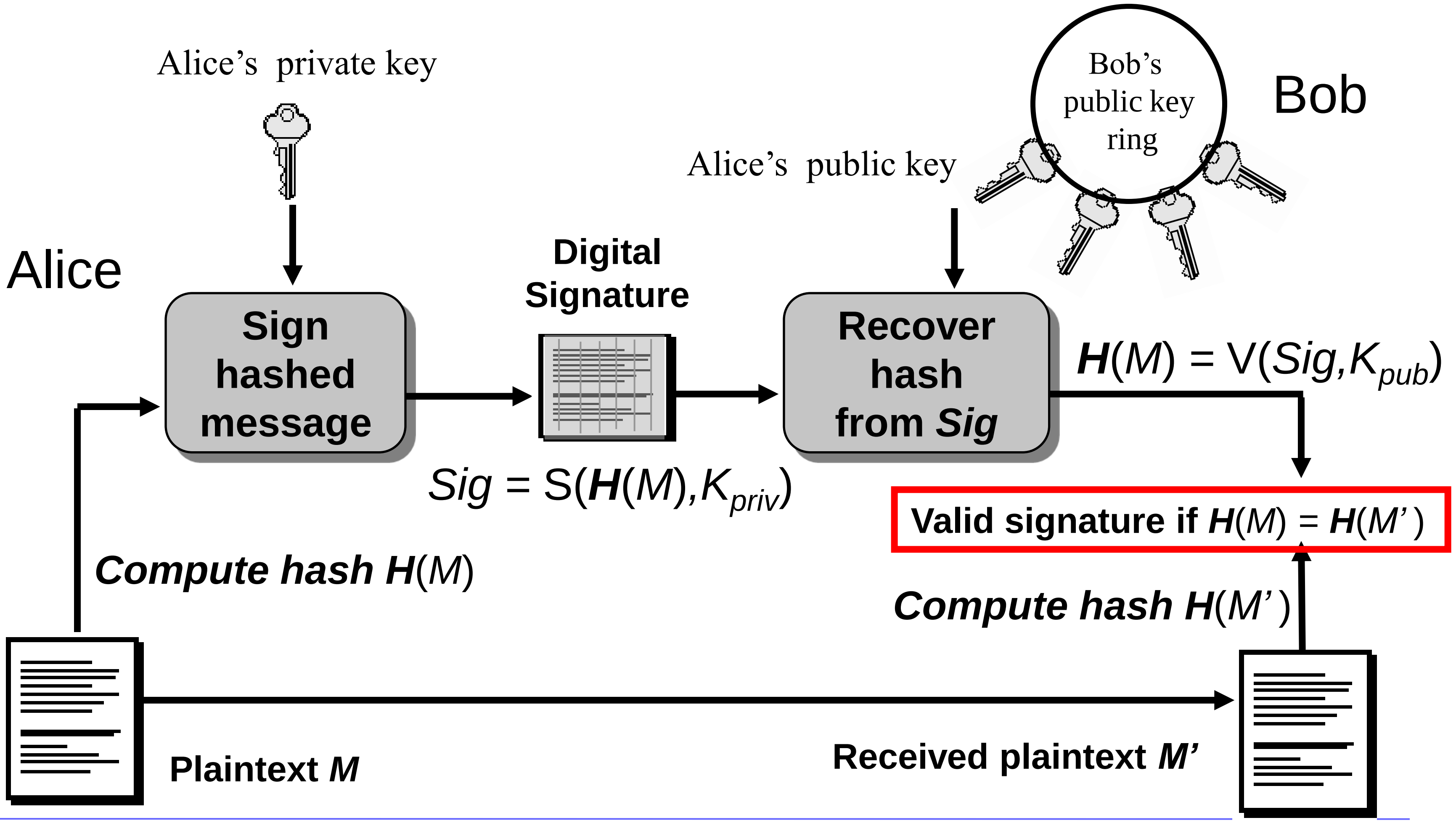
Public-key register
Alice: $\cancel{K_{pub}}(A)$ $K'_{pub}(A)$
Bob: $K_{pub}(B)$
Claire: $K_{pub}(C)$
False key
Attacker
Alice
Bob
M, Sig(M)=E[H(M), K_{priv}(A)]
E[M, K_{sec}], E[K_{sec}, K'_{publ}(A)]

- This breaks the security because:
  - a valid digital signature from Alice will be rejected
  - a confidential message to Alice can be read by attacker

Signing public keys

- **Integrity and trustworthiness of public keys:**
  - How can a user be sure who a public key belongs to?
  - How can a user be sure a public key has not been altered - intentionally or unintentionally?
- **Public keys must be distributed securely**
  - Use public-key certificates (aka. digital certificates) issued by a trusted third party
    - a Certification Authority (CA).
  - A public-key certificate is a public key digitally signed by a CA.
  - A hierarchy of public-key certificates becomes a PKI.

Digital signature generation and validation



Alice's private key
Bob's public key ring
Bob
Alice's public key
Alice
Digital Signature
Sign hashed message
Recover hash from *Sig*
$\boldsymbol{H}(M) = \mathrm{V}(Sig, K_{pub})$
$Sig = \mathrm{S}(\boldsymbol{H}(M), K_{priv})$
Valid signature if $\boldsymbol{H}(M) = \boldsymbol{H}(M')$
Compute hash H(*M*)
Compute hash H(*M'*)
Plaintext *M*
Received plaintext *M'*

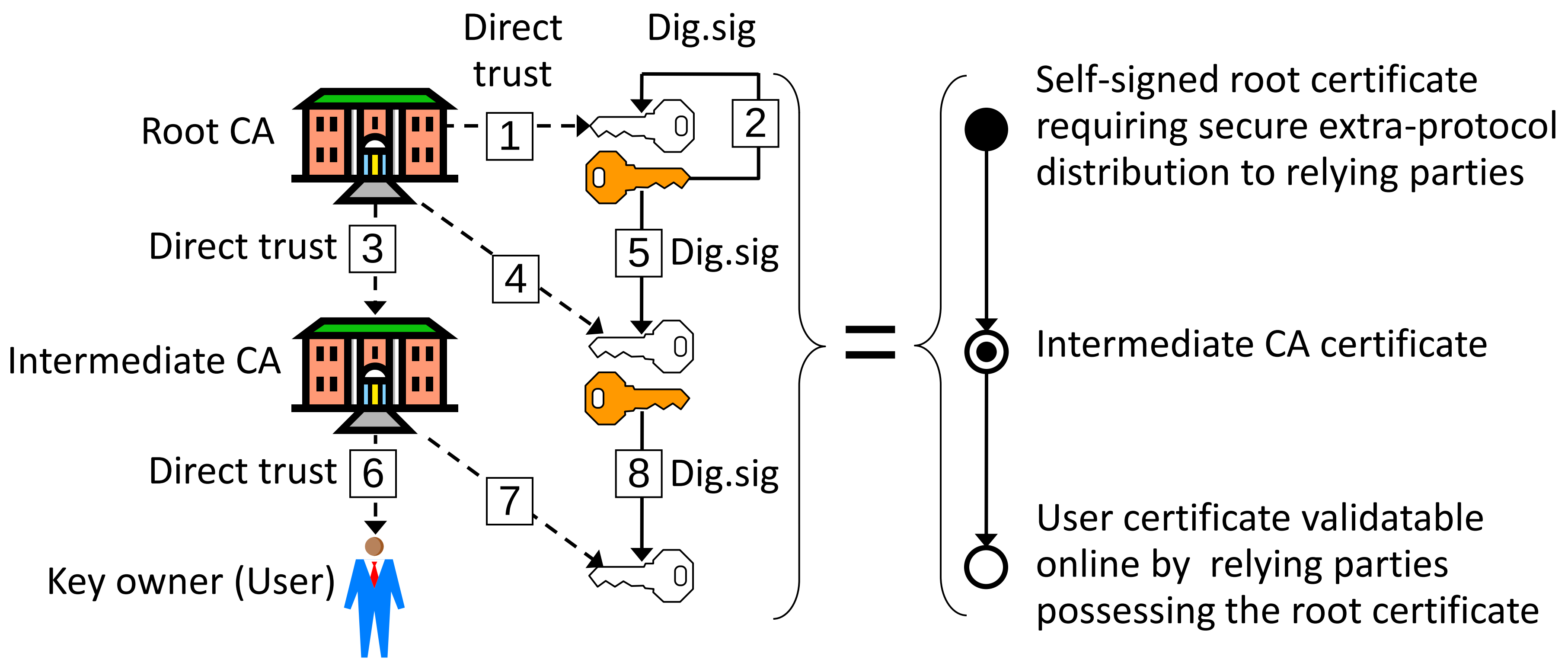
Digital signature notations

- Cryptographic terminology and notation:
  - Private Key $\mathbf{K_{priv}}$: confidential key only known by owner
  - Public Key $\mathbf{K_{pub}}$: publicly known key
  - Plaintext message **M**: the original message or data
  - Hash function **H**: used to create hash block
  - Digital signature Sig: cryptographic authentication code
  - Signature generation **S**: Function for creating the digital signature Sig of hash H(M) on message M
    - i.c.o. RSA, the S (sign) function is equivalent to D (decrypt)
  - Verification function **V**: Function for verifying the digital signature Sig of hash H(M) on message M
    - i.c.o. RSA, the V (verify) function is equivalent to E (encrypt)

Public-key infrastructure

- Due to spoofing problem, public keys must be digitally signed before distribution.
- PKI is an infrastructure for distributing signed public keys in the form of public-key certificates
- PKI consists of:
  - **Policies** (to define the rules for managing certificates)
  - **Technologies** (to implement the policies and generate, store and manage certificates)
  - **Procedures** (related to key management)
  - **Structure of public key certificates** (public keys with digital signatures)

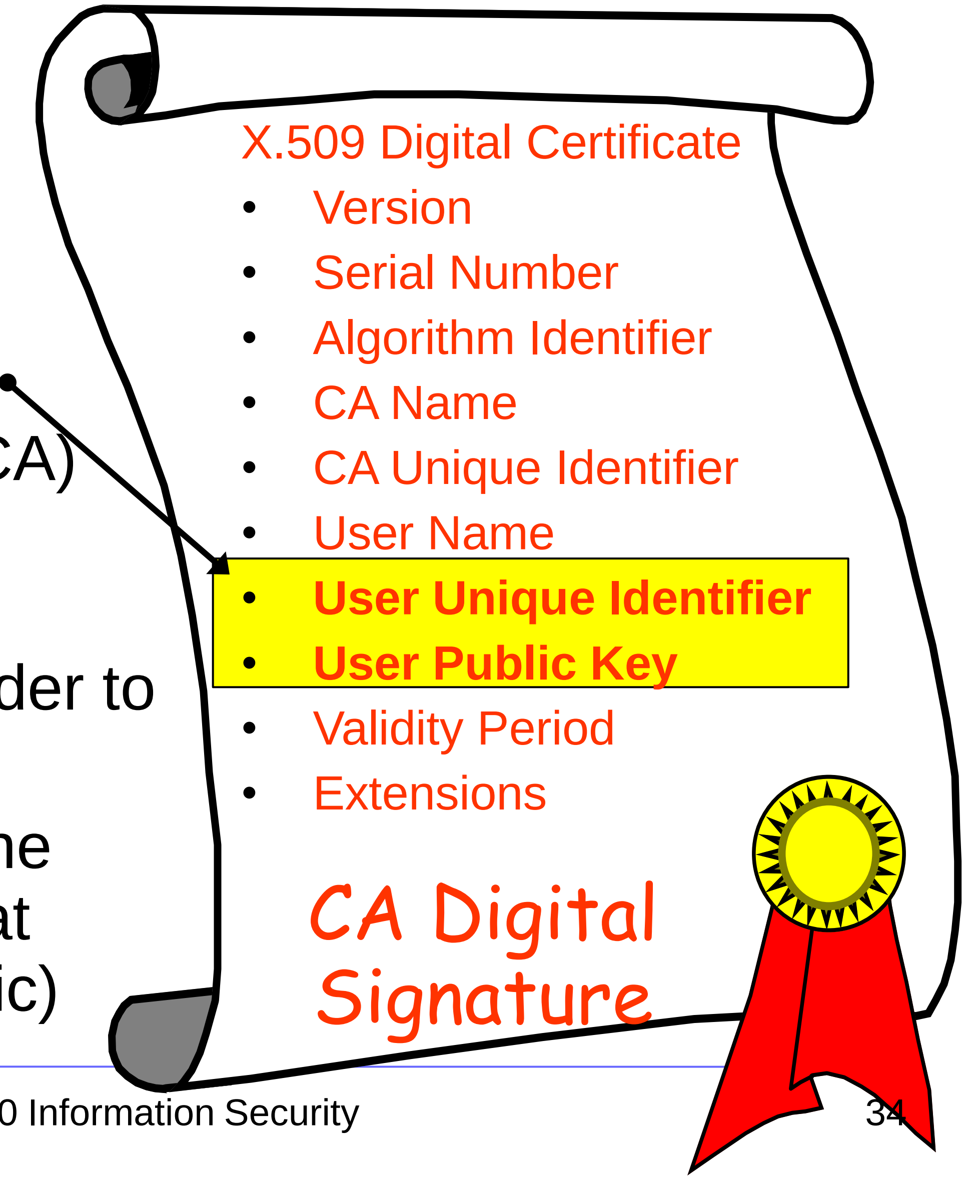
Certificate signature chain


Direct trust
Dig.sig
Root CA
1
2
Direct trust 3
4
5 Dig.sig
Intermediate CA
Direct trust 6
7
8 Dig.sig
Key owner (User)
=
Self-signed root certificate requiring secure extra-protocol distribution to relying parties
Intermediate CA certificate
User certificate validatable online by relying parties possessing the root certificate

Legend: Public key Private key

Public-Key Certificates

- A public-key certificate is simply a public key with a digital signature
- Binds name to public key
- Certification Authorities (CA) sign public keys.
- An authentic copy of CA's public key is needed in order to validate certificate
- **Relying party** validates the certificate (i.e. verifies that user public key is authentic)

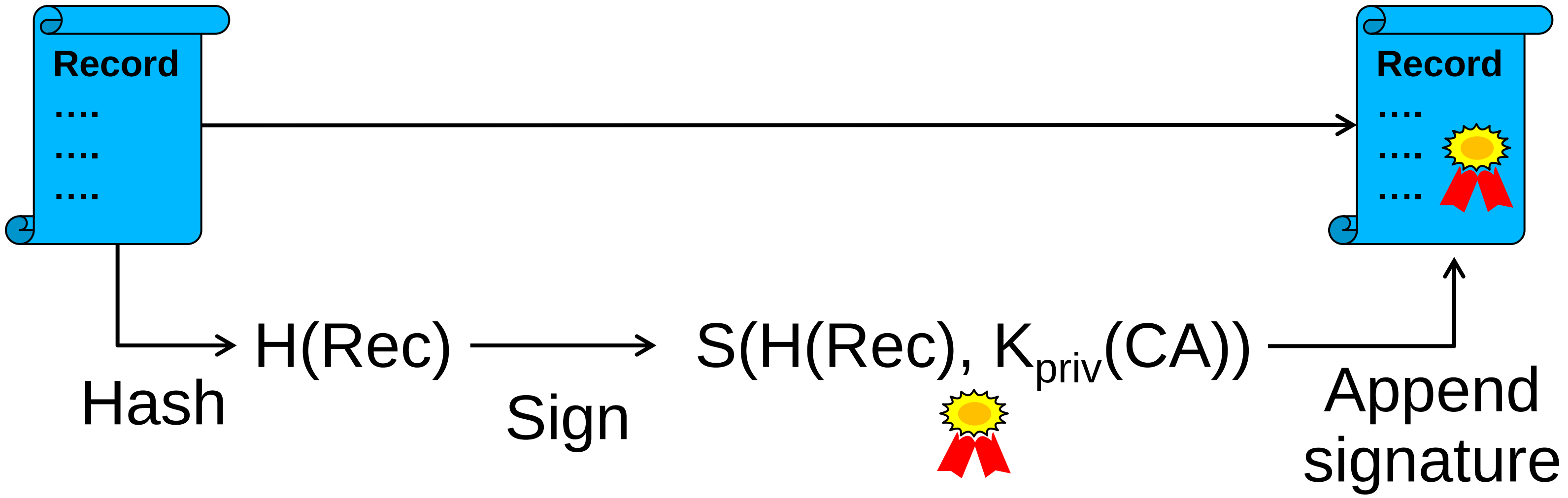

X.509 Digital Certificate

- Version
- Serial Number
- Algorithm Identifier
- CA Name
- CA Unique Identifier
- User Name
- **User Unique Identifier**
- **User Public Key**
- Validity Period
- Extensions

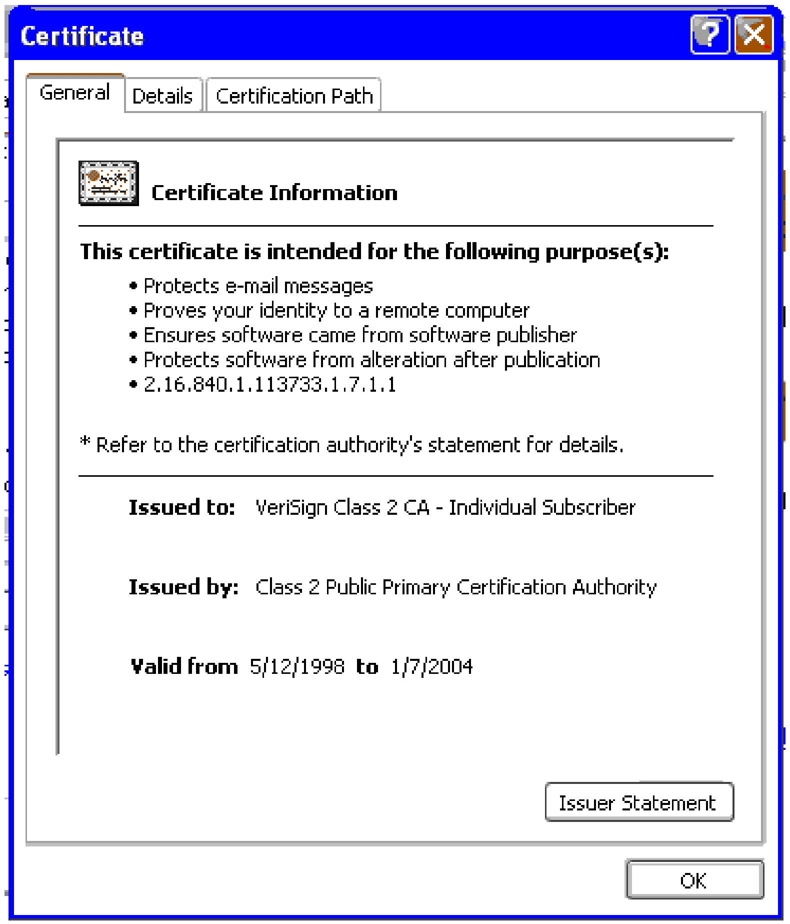
CA Digital Signature

How to generate a digital certificate?

1. Assemble the information in single record Rec
2. Hash the record
3. Sign the hashed record
4. Append the digital signature to the record



Example of X.509 certificate



Certificate

General | Details | Certification Path

Certificate Information

This certificate is intended for the following purpose(s):

- Protects e-mail messages
- Proves your identity to a remote computer
- Ensures software came from software publisher
- Protects software from alteration after publication
- 2.16.840.1.113733.1.7.1.1

* Refer to the certification authority's statement for details.

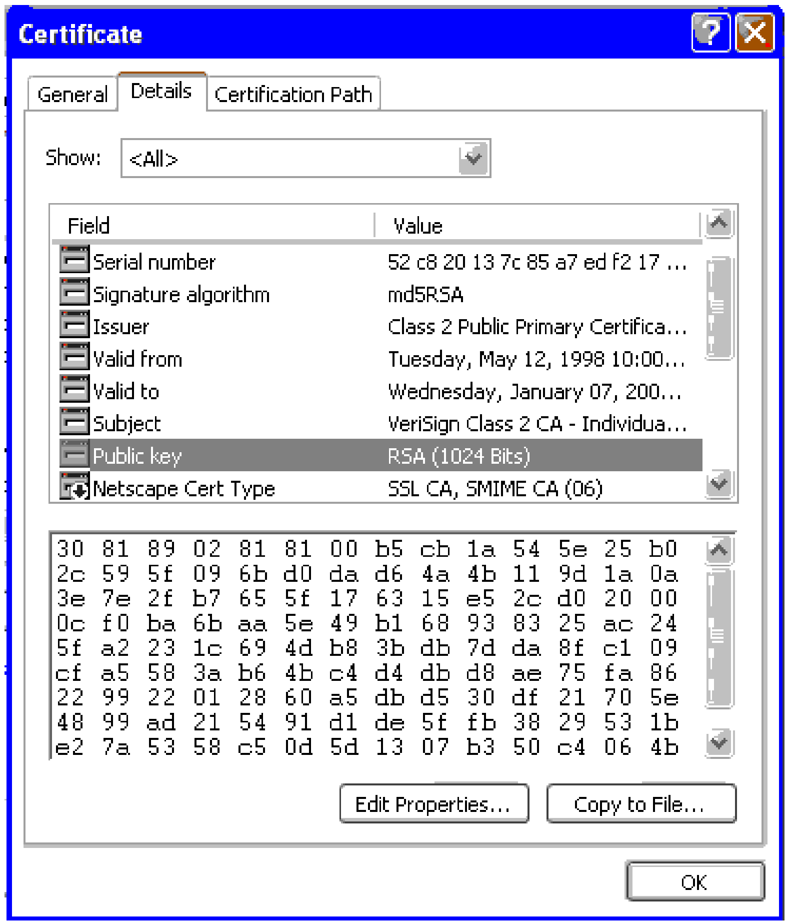
Issued to: VeriSign Class 2 CA - Individual Subscriber

Issued by: Class 2 Public Primary Certification Authority

Valid from 5/12/1998 **to** 1/7/2004

Issuer Statement

OK



Certificate

General | Details | Certification Path

Show: <All>

Field	Value
Serial number	52 c8 20 13 7c 85 a7 ed f2 17 ...
Signature algorithm	md5RSA
Issuer	Class 2 Public Primary Certifica...
Valid from	Tuesday, May 12, 1998 10:00...
Valid to	Wednesday, January 07, 200...
Subject	VeriSign Class 2 CA - Individua...
Public key	RSA (1024 Bits)
Netscape Cert Type	SSL CA, SMIME CA (06)

```
30 81 89 02 81 81 00 b5 cb 1a 54 5e 25 b0
2c 59 5f 09 6b d0 da d6 4a 4b 11 9d 1a 0a
3e 7e 2f b7 65 5f 17 63 15 e5 2c d0 20 00
0c f0 ba 6b aa 5e 49 b1 68 93 83 25 ac 24
5f a2 23 1c 69 4d b8 3b db 7d da 8f c1 09
cf a5 58 3a b6 4b c4 d4 db d8 ae 75 fa 86
22 99 22 01 28 60 a5 db d5 30 df 21 70 5e
48 99 ad 21 54 91 d1 de 5f fb 38 29 53 1b
e2 7a 53 58 c5 0d 5d 13 07 b3 50 c4 06 4b
```

Edit Properties... | Copy to File...

OK

Using certificates to send confidential data

Alice wants to send confidential $C = E(M, K_{pub}(B))$ to Bob

1. Alice is the relying party and must get Bob's public key
   - Alice can obtain $Cert_B$
   - Alice validates $Cert_B$
   - Alice obtains $K_{pub}(B)$ from $Cert_B$
2. Alice uses $K_{pub}(B)$ to encrypt message M

- If Alice
  - trusts the CA that issued $Cert_B$ (i.e. to be competent and honest)
  - and is certain of CA's public key and unique identifier
  - and is certain of Bob's unique identifier
- then Alice can be sure that **only** Bob can read message
- Message M can be a secret session key.

Using certificates to verify signatures

Bob sends signed message {M, Sig_B(H(M)), $Cert_B$} to Alice

H(M) is the hash value of message M.

1. Alice is the relying party and must first validate $Cert_B$
   - Alice uses CA's public key K_{pub}(CA) to verify CA's signature on the binding between the public key and Bob's unique identifier.
2. Alice obtains K_{pub}(B) from the certificate $Cert_B$
3. Alice uses K_{pub}(B) to verify signature Sig_B(H(M)) on M

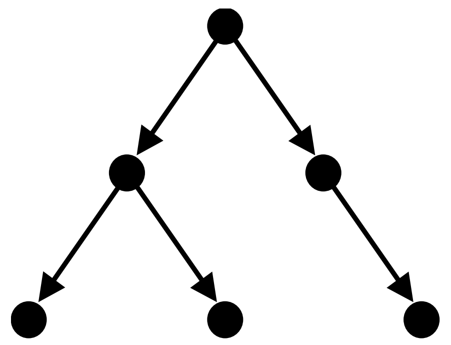
- If Alice
  – trusts the CA that issued $Cert_B$ (i.e. to be competent and honest)
  – and is certain of CA's public key and unique identifier
  – and is certain of Bob's unique identifier
- then Alice is certain that message M came from Bob

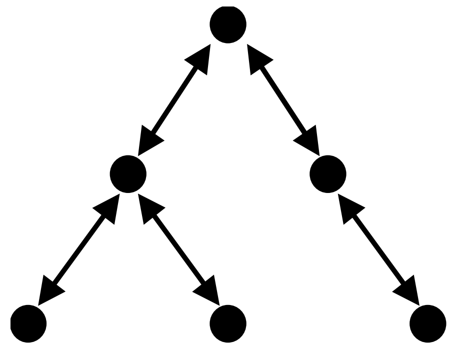
Self-signed root keys: Why?

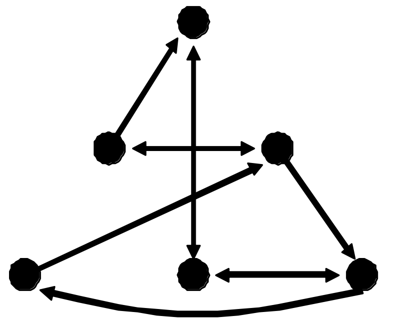
- Many people think a root public key is authentic just because it is self-signed
- Not a coincidence
  - Gives impression of assurance
  - Disguises insecure practice
  - Give false trust

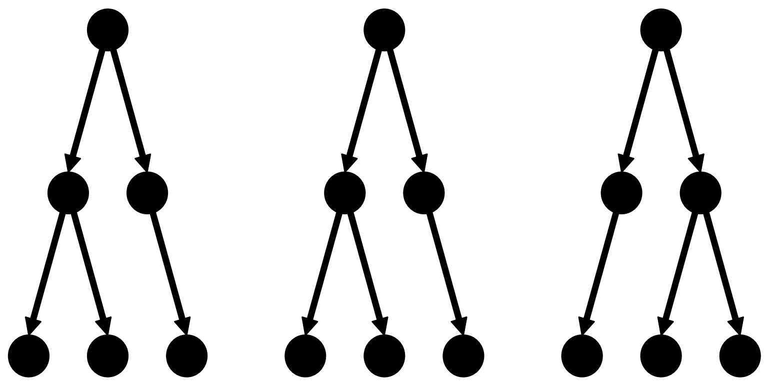
- Self-signing provides absolutely no security
- Possible use of self-signing
  - X.509 certificates have a field for digital signature, and an empty field might cause applications to malfunction, so a self signature is a way to fill the empty field
  - Self-signature can be used to specify a cert as a root

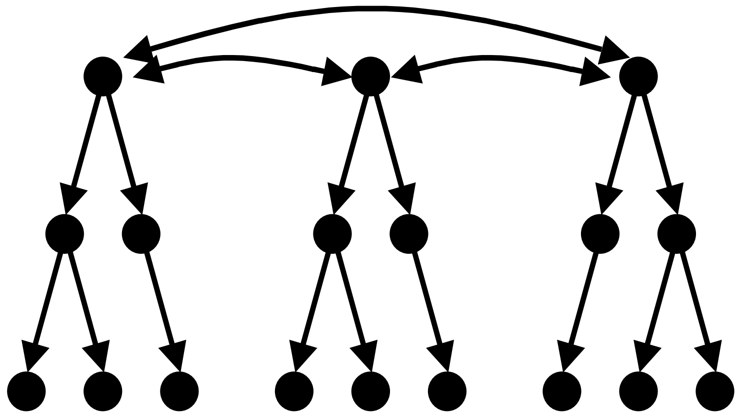
PKI Trust Models


Strict hierarchy

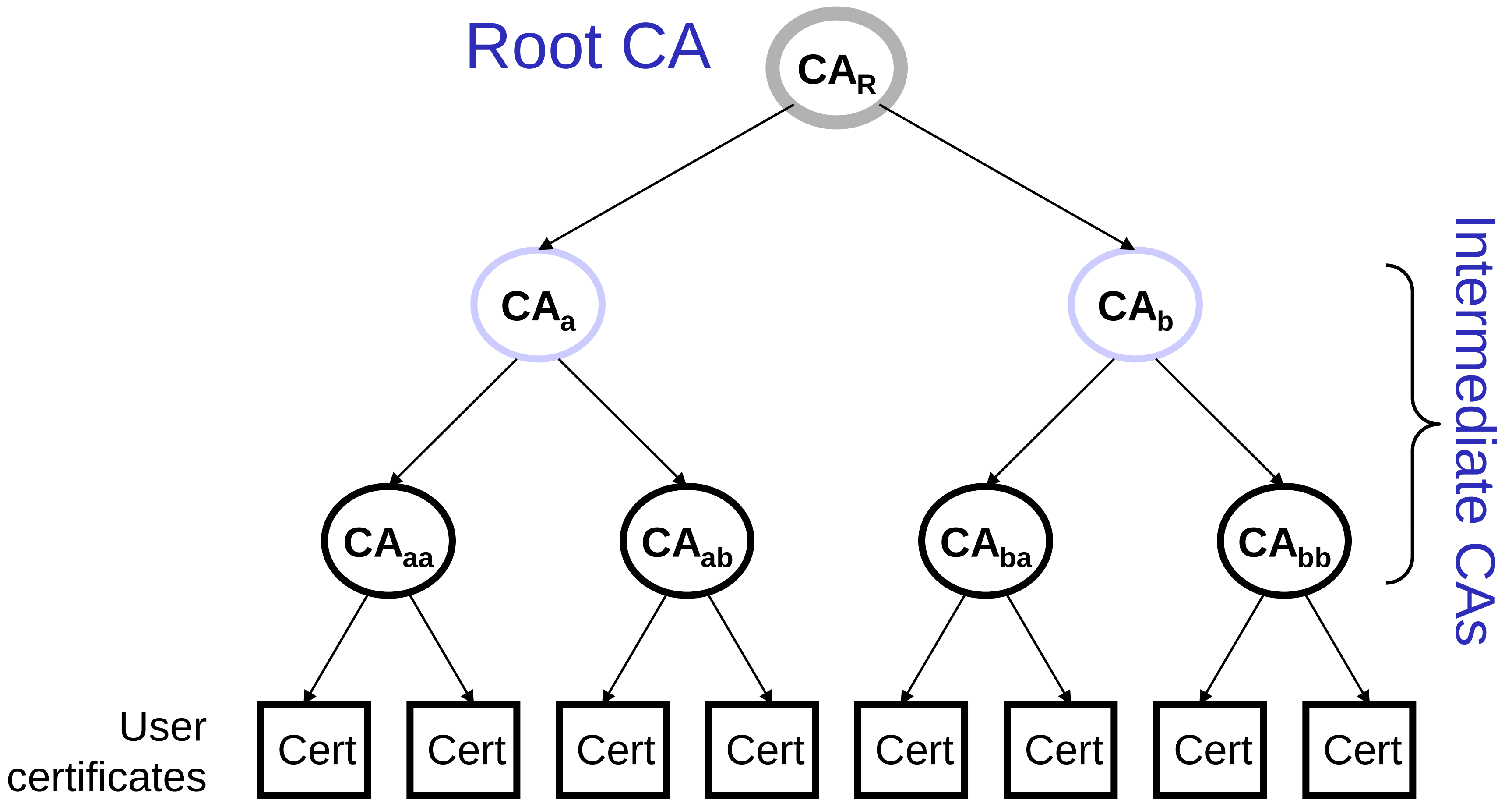

General hierarchy


Mesh model / User-centric model


Isolated strict hierarchies: "Browser PKI"


Cross certified strict hierarchies

PKI trust models
Strict hierarchical model



PKI trust models
Strict hierarchical model

- Highly regulated
  - each CA must follow rules regarding to whom they may issue certificates
- Tree structure
  - Single root CA
  - Users are leaves of the tree
  - Each node is certified by its immediate parent CA
- Root CA
  - Starting point for trust
  - All users trust the root CA, and must receive its public key through a secure out-of-band channel

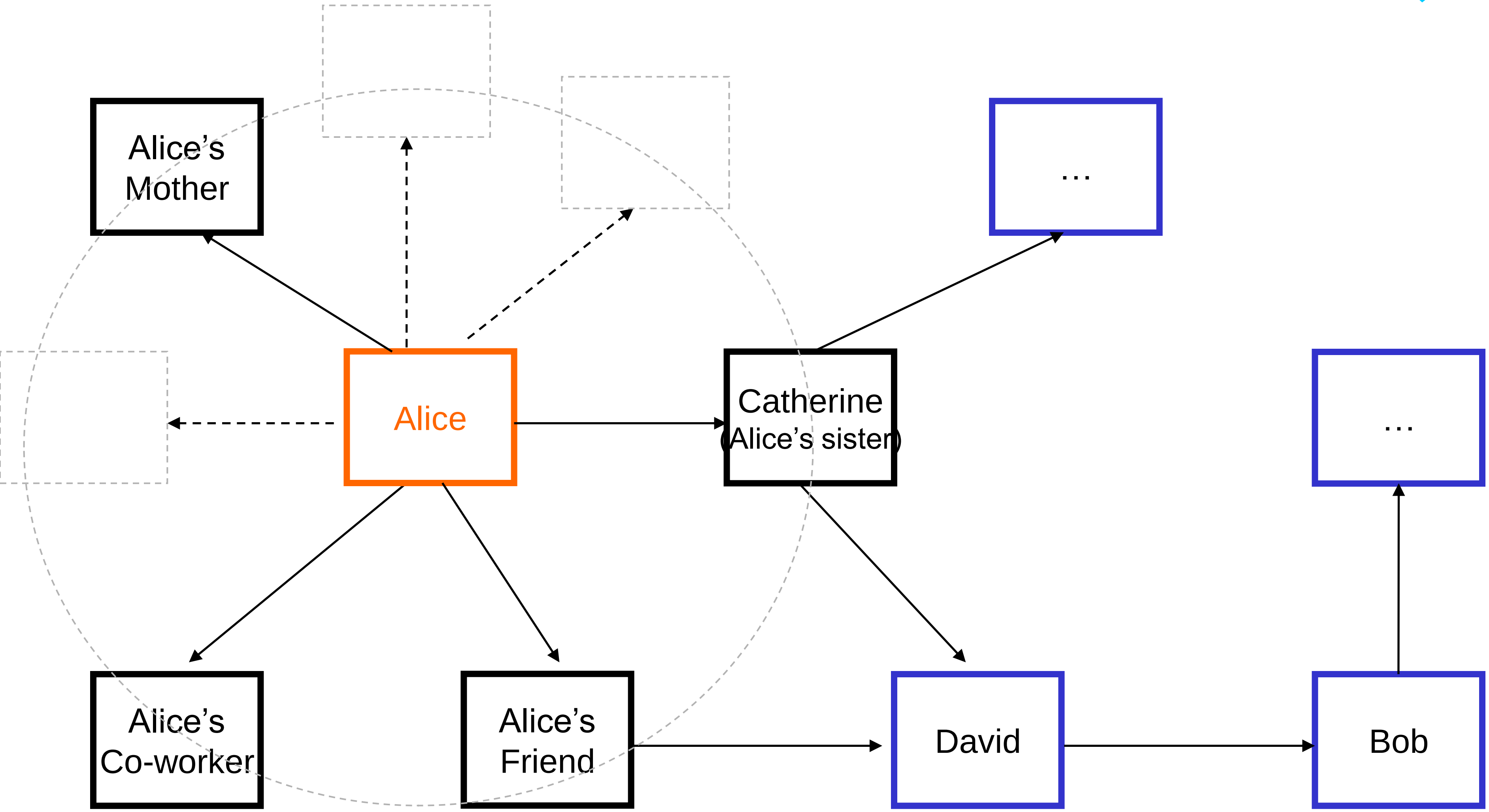
PKI trust models
Strict hierarchical model

- Advantages:
  - works well in highly-structured setting such as military and government
  - unique certification path between two entities (so finding certification paths is trivial)
  - scales well to larger systems
- Disadvantages:
  - need a trusted third party (root CA)
  - ‘single point-of-failure’ target
  - If any node is compromised, trust impact on all entities stemming from that node
  - Does not work well for global implementation (who is root TTP?)

Diagram

PKI trust models

User-centric model, as in PGP



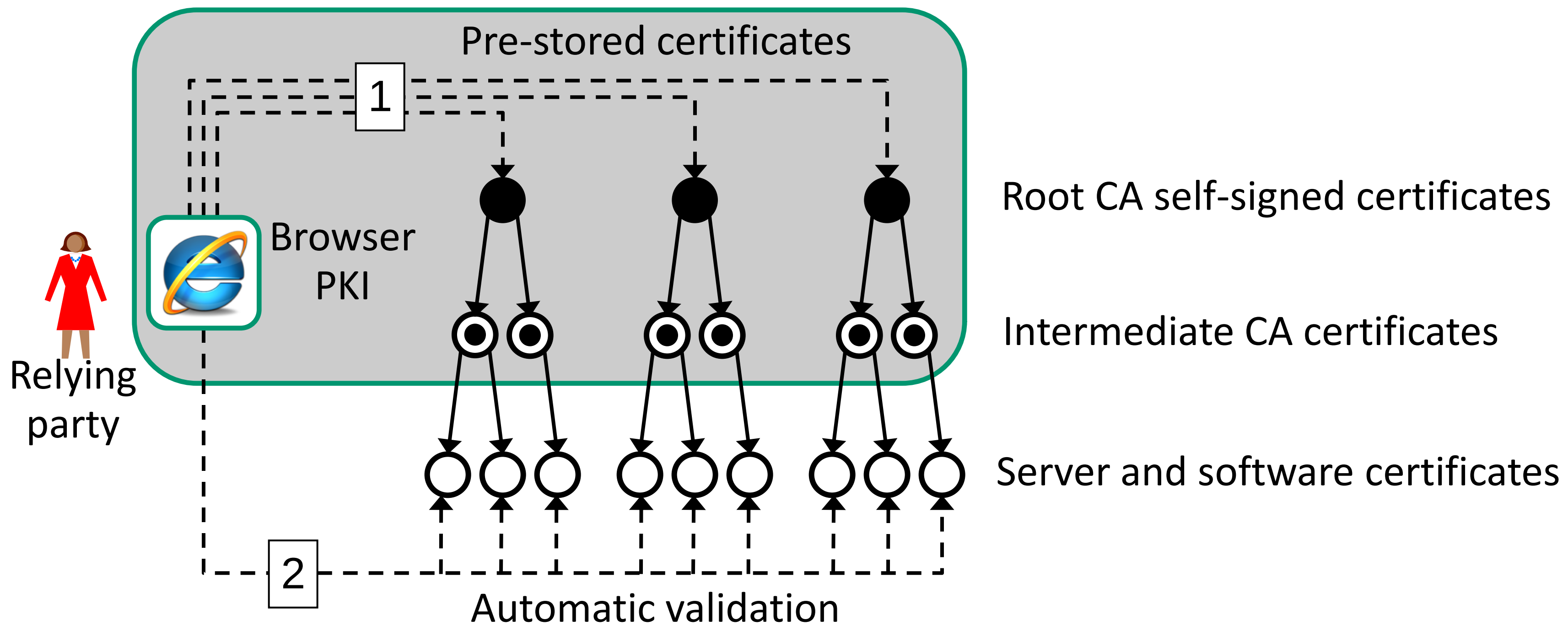
PKI trust models
User-centric model

- Each user is **completely responsible** for deciding which public keys to trust
- Example: *Pretty Good Privacy (PGP)*
  - ‘Web of Trust’
  - Each user may act as a CA, signing public keys that they will trust
  - Public keys can be distributed by key servers and verified by fingerprints
  - OpenPGP Public Key Server: http://pgpkeys.mit.edu:11371/
- PGP or GPG – What is the difference?

PKI trust models
User-centric model

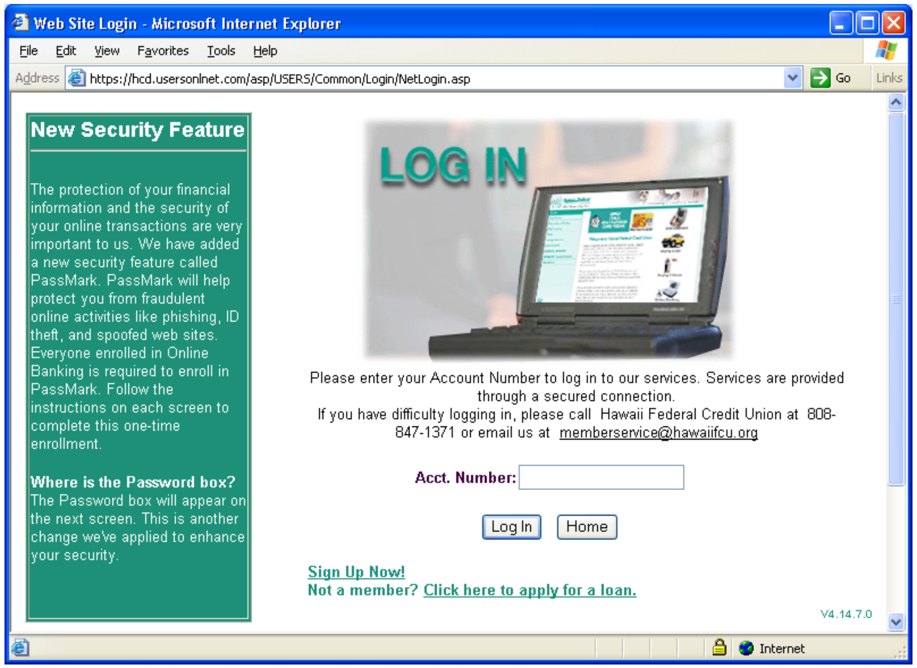
- Advantages:
  - Simple and free
  - Works well for a small number of users
  - Does not require expensive infrastructure to operate
  - User-driven grass roots operation
- Disadvantages:
  - More effort, and relies on human judgment
    - Works well with technical users who are aware of the issues, but not the general public
  - Not appropriate for more trust-sensitive areas such as finance and government

The Browser PKI


Pre-stored certificates
1
Browser
PKI
Relying
party
Root CA self-signed certificates
Intermediate CA certificates
Server and software certificates
2
Automatic validation

The browser PKI model consists of isolated strict hierarchies where the (root) CA certificates are installed as part of the web browser. New roots and trusted certificates can be imported after installation

Phishing and fake certificates
Hawaii Federal Credit Union


Web Site Login - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address https://hcd.usersonlnet.com/asp/USERS/Common/Login/NetLogin.asp
Go Links
LOG IN
Internet

New Security Feature

The protection of your financial information and the security of your online transactions are very important to us. We have added a new security feature called PassMark. PassMark will help protect you from fraudulent online activities like phishing, ID theft, and spoofed web sites. Everyone enrolled in Online Banking is required to enroll in PassMark. Follow the instructions on each screen to complete this one-time enrollment.

Where is the Password box?
The Password box will appear on the next screen. This is another change we've applied to enhance your security.

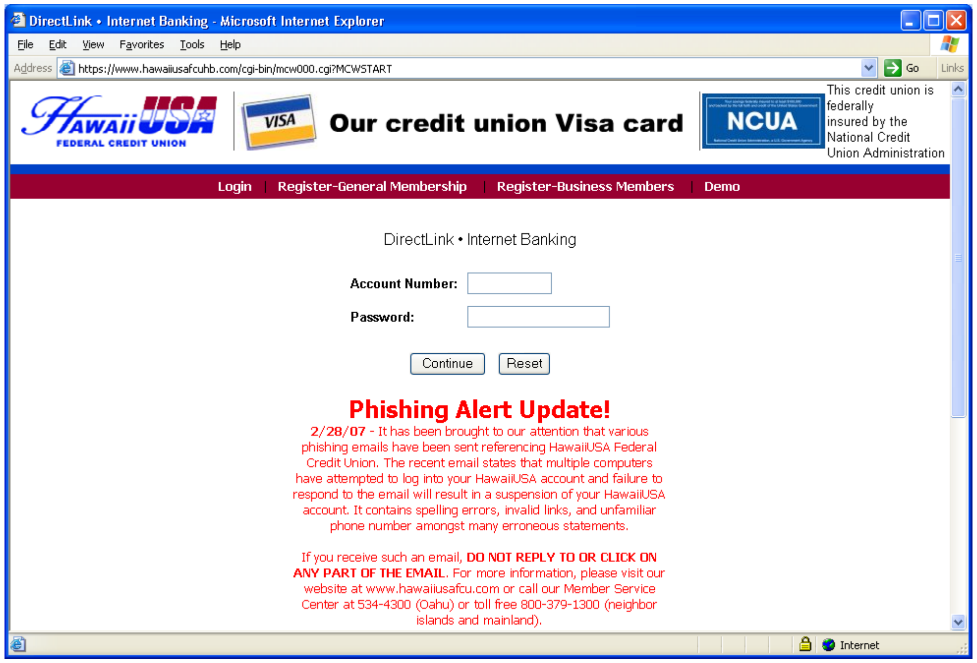
Please enter your Account Number to log in to our services. Services are provided through a secured connection.
If you have difficulty logging in, please call Hawaii Federal Credit Union at 808-847-1371 or email us at memberservice@hawaiifcu.org

Acct. Number:

Log In | Home

Sign Up Now!
Not a member? Click here to apply for a loan.

V4.14.7.0


DirectLink • Internet Banking - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address https://www.hawaiiusafcuhb.com/cgi-bin/mcw000.cgi?MCWSTART
Go Links
HawaiiUSA FEDERAL CREDIT UNION
VISA
Our credit union Visa card
NCUA
Internet

This credit union is federally insured by the National Credit Union Administration

Login | Register-General Membership | Register-Business Members | Demo

DirectLink • Internet Banking

Account Number:

Password:

Continue | Reset

Phishing Alert Update!

2/28/07 - It has been brought to our attention that various phishing emails have been sent referencing HawaiiUSA Federal Credit Union. The recent email states that multiple computers have attempted to log into your HawaiiUSA account and failure to respond to the email will result in a suspension of your HawaiiUSA account. It contains spelling errors, invalid links, and unfamiliar phone number amongst many erroneous statements.

If you receive such an email, **DO NOT REPLY TO OR CLICK ON ANY PART OF THE EMAIL**. For more information, please visit our website at www.hawaiiusafcu.com or call our Member Service Center at 534-4300 (Oahu) or toll free 800-379-1300 (neighbor islands and mainland).

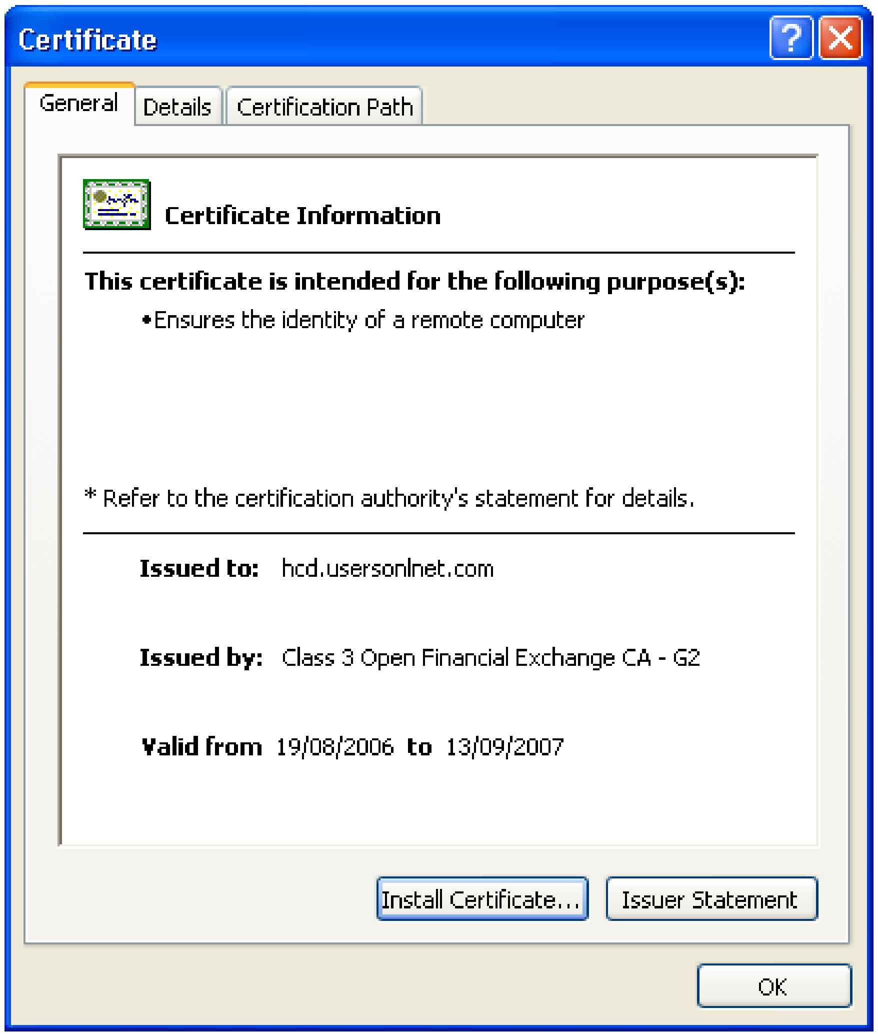
Authentic bank login

https://hcd.usersonlnet.com/asp/USERS/Common/Login/NettLogin.asp

Fake bank login

https://hawaiiusafcuhb.com/cgi-bin/mcw00.cgi?MCWSTART

Authentic and Fake Certificates



Certificate Information

This certificate is intended for the following purpose(s):
- Ensures the identity of a remote computer

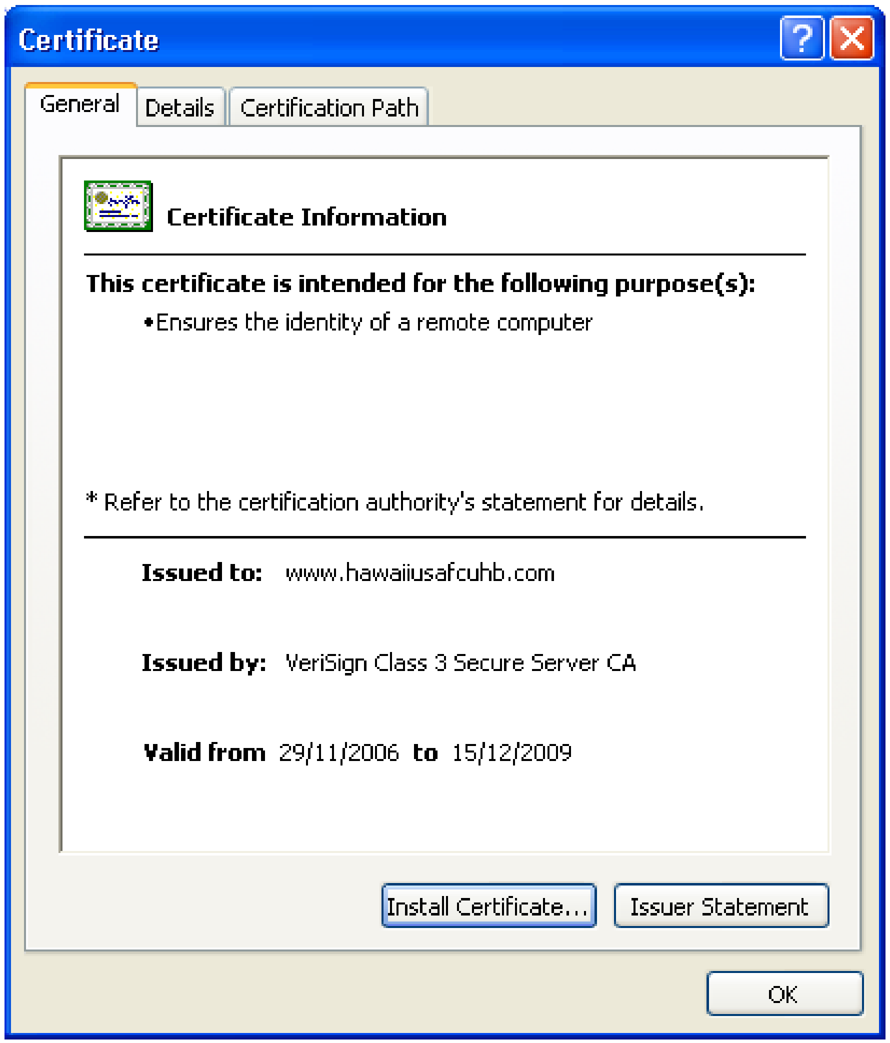
* Refer to the certification authority's statement for details.

Issued to: hcd.usersonlnet.com

Issued by: Class 3 Open Financial Exchange CA - G2

Valid from 19/08/2006 to 13/09/2007

Authentic certificate



Certificate Information

This certificate is intended for the following purpose(s):
- Ensures the identity of a remote computer

* Refer to the certification authority's statement for details.

Issued to: www.hawaiiusafcuhb.com

Issued by: VeriSign Class 3 Secure Server CA

Valid from 29/11/2006 to 15/12/2009

Fake certificate

Browser PKI and malicious certificates

- The browser automatically validates certificates by checking that the certificate name and the domain name of web server are equal
- Criminals buy legitimate certificates which are automatically validated by browsers
  - Legitimate certificates can be used for malicious phishing attacks, e.g. to masquerade as a bank
  - **Malicious certificates are legitimate certificates !!!**
- Server certificate validation is not authentication
  - Users who don’t know the server domain name cannot distinguish between right and wrong server certificates

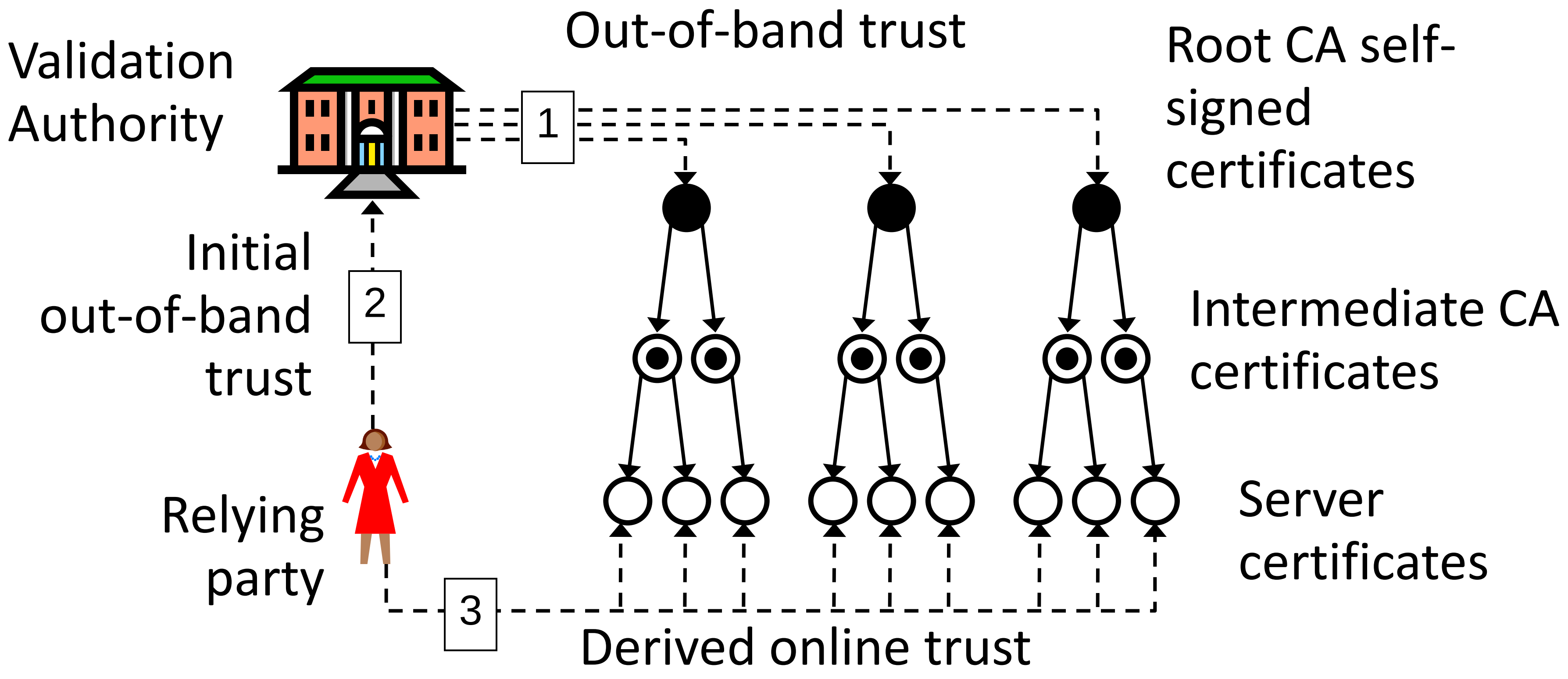
Browser PKI root certificate installation

- Distribution of root certificates which should happen securely out-of-band, is often done through online downloading of browser SW
- Users are in fact trusting the browser vendor who supplied the installed certificates, rather than a root CA
- Example: used by *Mozilla Firefox* and *Microsoft Internet Explorer*
- Browser vendors decide which CA certs to distribute with browsers
  – This is an important political issue

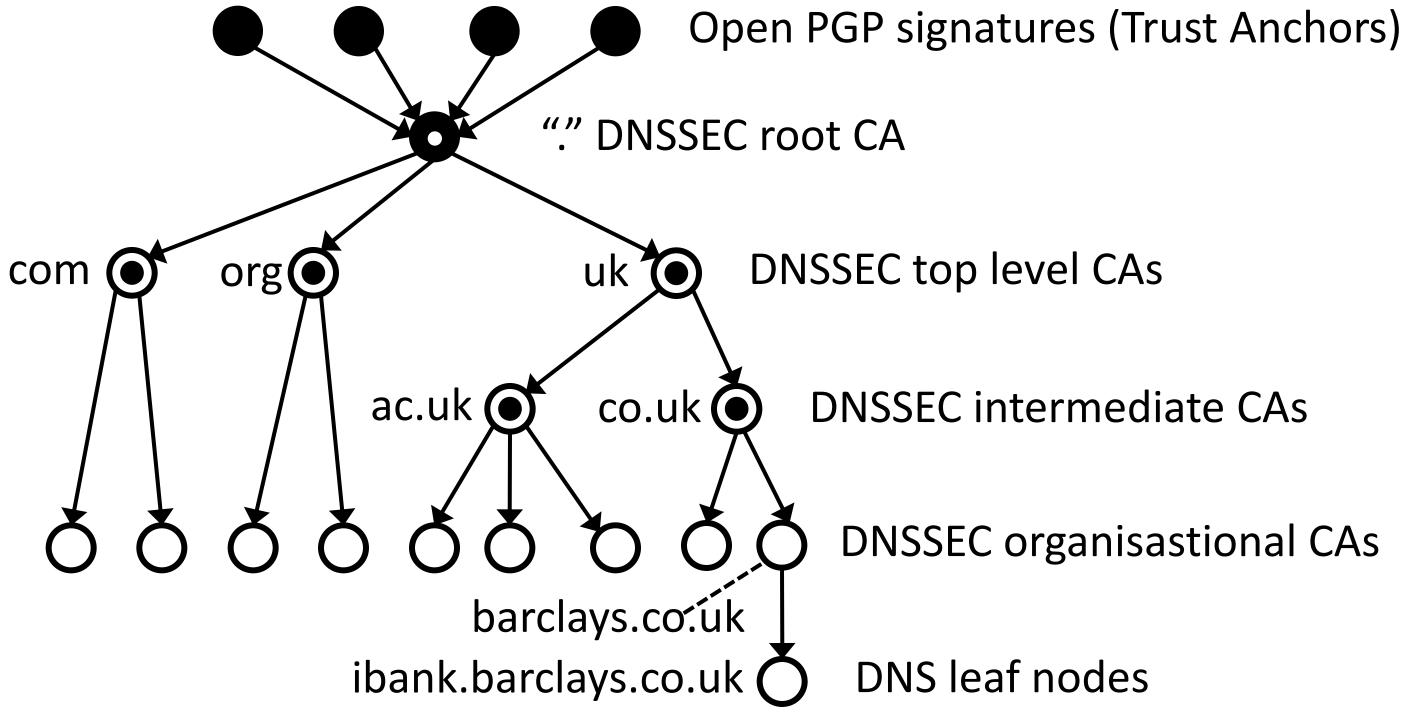
PKI components
Validation Authority

- **Q: What if the relying party needs to validate a certificate but can't establish a trust path to it?**
- **A:** The relying party can use a validation service from a VA (Validation Authority) to validate the certificate
  - The relying party needs to trust the VA
  - The relying party needs an authentic copy of the VA's public key, e.g. received securely out-of-band
- The VAs must establish trust relationships and get authentic public keys from Root CAs of many different PKIs

PKI Components
Validation Authorities

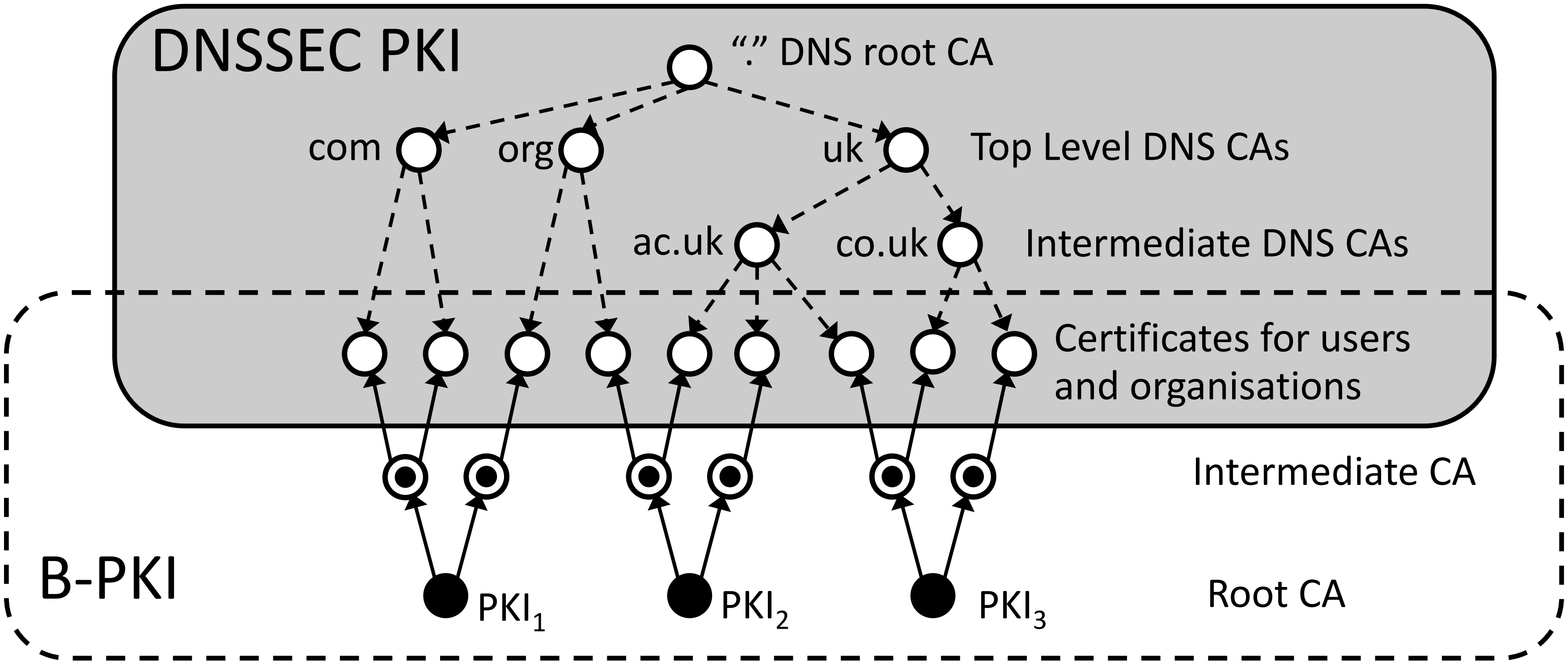


DNSSEC PKI



- The DNS (Domain Name System) is vulnerable to e.g. cache poisoning attacks resulting in wrong IP addresses being returned.
- DNSSEC designed to provide digital signature on every DNS reply
- Based on PKI with a single root.

Adjacent DNSSEC PKI and Browser PKI



- The DNSSEC PKI and the B-PKI both target the same user/org nodes
- Vulnerabilities in B-PKI due to multiple separate PKIs where any CA can issue certificates for any domain. Several security incidents reported.
- CAs under the DNSSEC PKI can only issue certificates for own domain

PKI components: CRL

- Certificate Revocation
  - **Q: When might a certificate need to be revoked ?**
  - **A:** When certificate becomes outdated **<u>before</u>** it expires, due to:
    - private key being disclosed
    - subscriber name change
    - change in authorisations, etc
- Revocation may be checked online against a certificate revocation list (CRL)
- Checking the CRL creates a huge overhead which threatens to make PKI impractical

PKI services

- Several organisations operate PKI services
  - Private sector
  - Public sector
  - Military sector
- Mutual recognition and cross certification between PKIs is difficult
- Can be expensive to operate a robust PKI
- The Browser PKI is the most widely deployed PKI thanks to piggy-backing on browsers and the lax security requirements

PKI Summary

- Public key cryptography needs a PKI to work
  - Digital certificates used to provide authenticity and integrity for public keys
  - Acceptance of certificates requires trust
  - Trust relationships between entities in a PKI can be modelled in different ways
  - Establishing trust has a cost, e.g. because secure out-of-band channels are expensive

End of lecture