Securing Fixed and Wireless Networks, COMP4337/9337
WK03-01: Certification Authority, Public Key Infrastrucutre

Never Stand Still

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Agenda

- Key distribution using asymmetric encryption
  - Public-key certificates
  - Public-key distribution of secret keys
  - Certification Authority and X.509

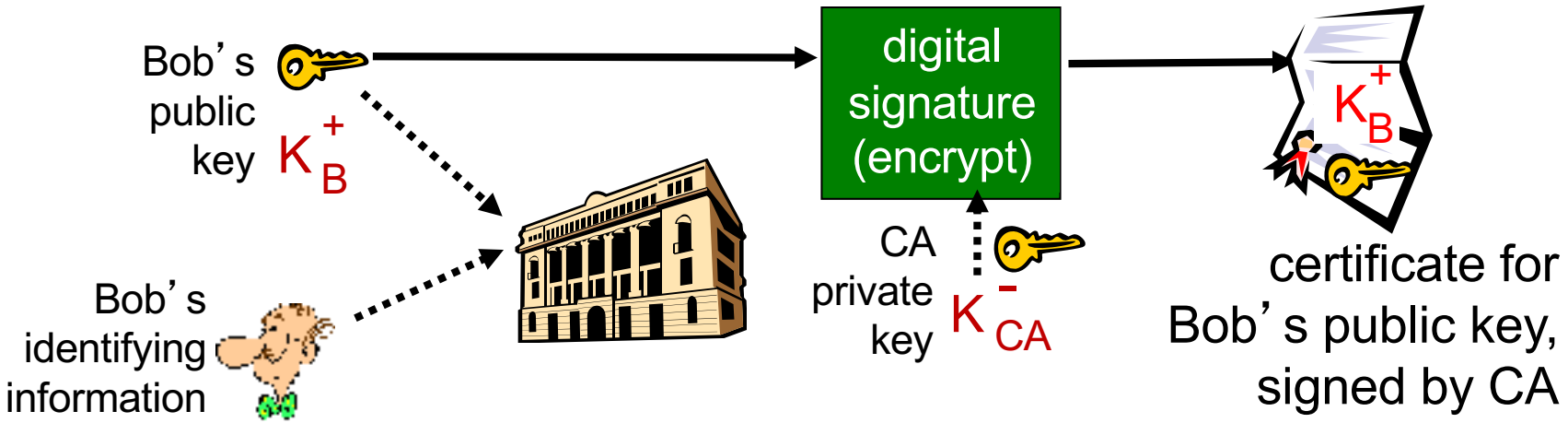
Public-key certification

- motivation: Trudy plays pizza prank on Bob
  - Trudy creates e-mail order:
    Dear Pizza Store, Please deliver to me four pepperoni pizzas. Thank you, Bob
  - Trudy signs order with her private key
  - Trudy sends order to Pizza Store
  - Trudy sends to Pizza Store her public key, but says it's Bob's public key
  - Pizza Store verifies signature; then delivers four pepperoni pizzas to Bob
  - Bob doesn't even like pepperoni

Certification authorities

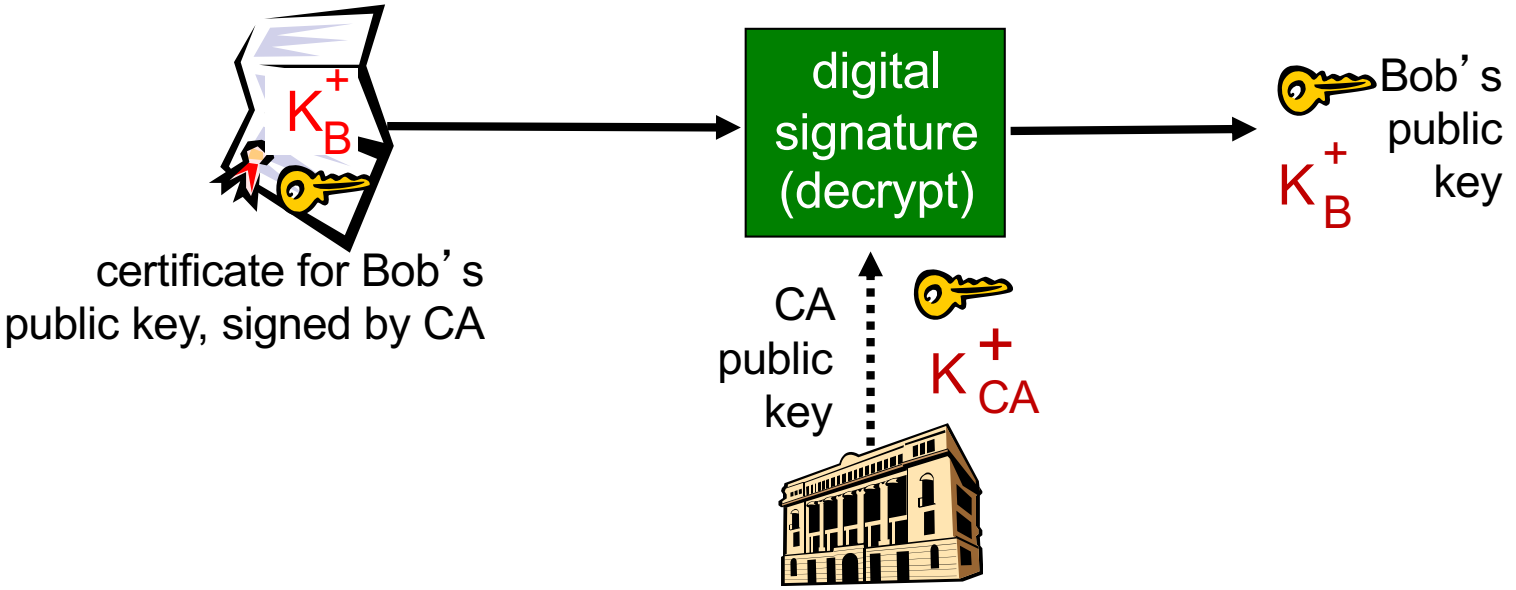
certification authority (CA): binds public key to particular entity, E.

- E (person, router) registers its public key with CA.
  - E provides "proof of identity" to CA.
  - CA creates certificate binding E to its public key.
  - certificate containing E's public key digitally signed by CA – CA says "this is E's public key"



Certification authorities

- when Alice wants Bob's public key:
  - gets Bob's certificate (Bob or elsewhere).
  - apply CA's public key to Bob's certificate, get Bob's public key



Public Key Distribution of Secret Key

- Prepare a message
- Encrypt that message using conventional encryption using one time session key
- Encrypt the session key using public-key encryption with Alice's **public key**
- Attach the encrypted session key to the message and send it to Alice
- Only Alice can decrypt the session key
- Bob has obtained Alice's public key by means of Alice's **public-key certificate**, must be a valid key

Note: Important technique used in several protocols

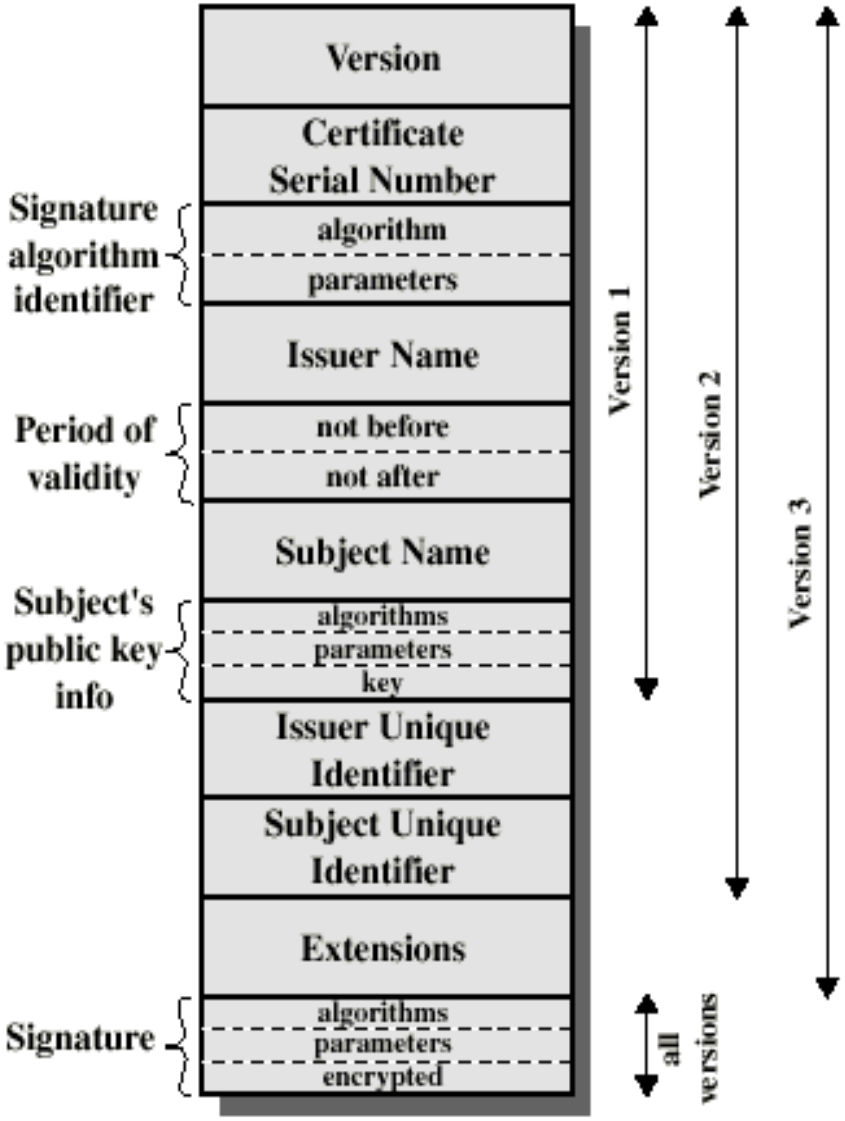
X.509 Authentication Service

- Distributed set of servers that maintains a database about users.
- Each certificate contains the public key of a user and is signed with the private key of a CA.
- Is used in S/MIME, IP Security, SSL/TLS and SET.
- RSA is recommended to use but not mandatory.
- Digital Signature is assumed to use Hash algorithm
- Digital Certificate: user's id, public-key and CA information as input to hash function. Hash is then encrypted with CA's private key to produce **Digital Certificate**

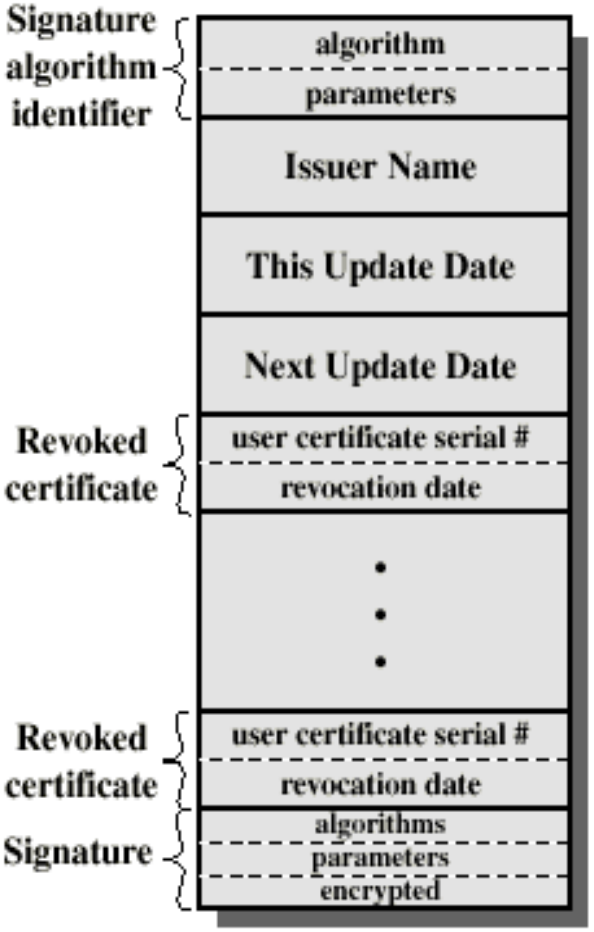
No need to memorise

Read: Stallings ch4 for a quick overview

X.509 Formats



(a) X.509 Certificate



(b) Certificate Revocation List

Distributed Directory

- Users can be registered with a CA and would know its public Key
- Now if A got its certificate from CA X1 and B got it from CA X2.
- If A doesn't know CA X2's public key, it can't trust B's certificate issued by CA X2.
- However, if the two CA's have securely exchanged their public keys, then it can work.
  - A obtains the certificate of X2 signed by X1 from directory
  - A knows securely X1's public key
  - A obtains X2's public key from its certificate and can verify using X1's signature on certificate
  - A can now get B's certificate from CA X2.
  - Since it has trusted public key for CA X2, things work as usual.

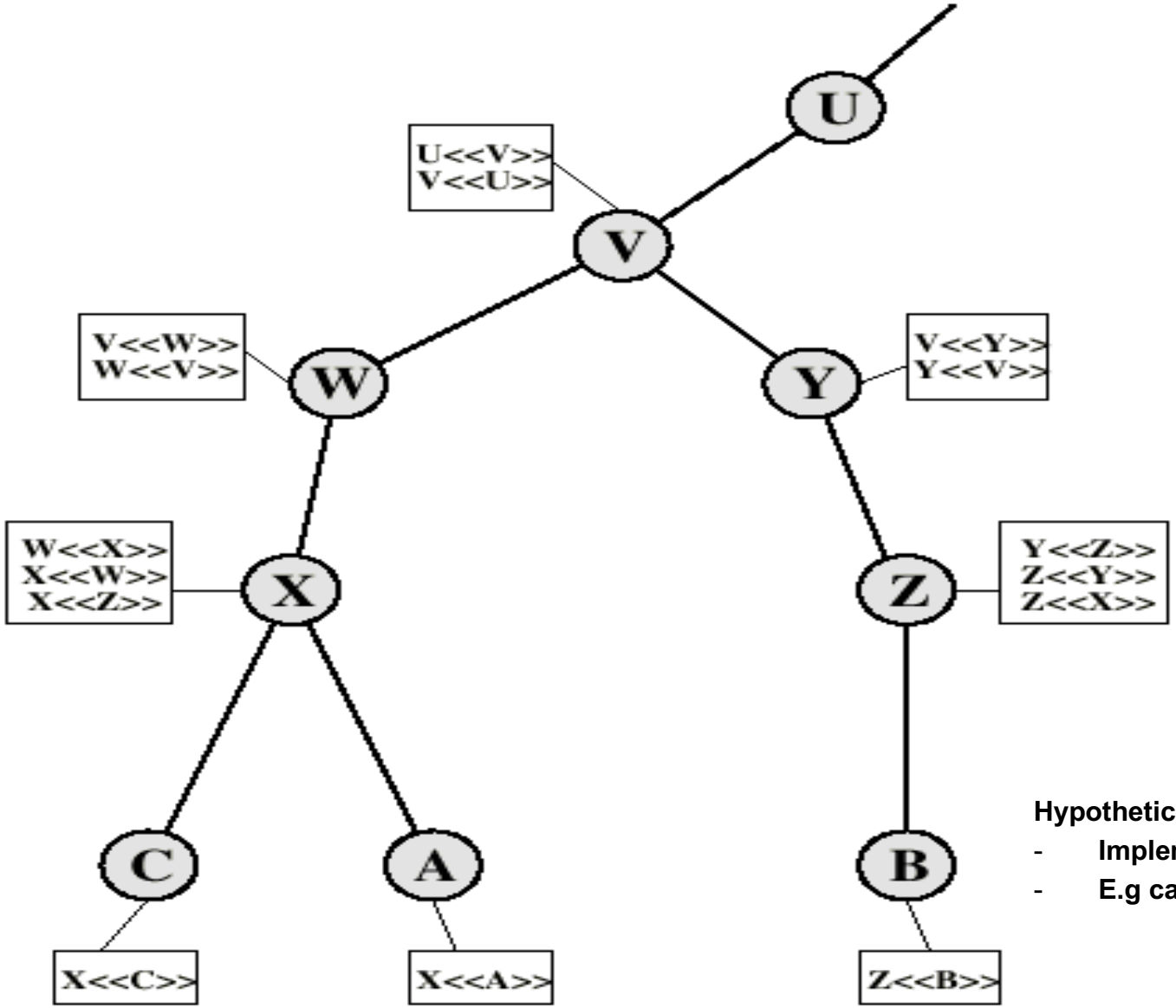
Distributed Directory: Certificate Chain

- Notation Y <<X>> Certificate of user X issued by authority Y
- A obtains B's public key using the following X.509 notation

  X_1 << X_2>> X_2 << B>>
- B obtains A's public key using the following X.509 notation

  X_2<< X_1>> X_1 << A>>
  - *Arbitrary chain is possible as long as consecutive pair (X_n, X_{n+1}) of CAs have exchanged certificates securely*

X.509 CA Hierarchy



Hypothetical Example

- **Implementations may vary**
- **E.g cache entries**

Hierarchy of CAs

- Previous figure: Connected Circles hierarchical relationship, boxes shows certificates maintained in each CA's directory
  - Forward Certs: Certs of X generated by other CAs (e.g at circle X, W<<X>>) – PARENT
  - Reverse Certs: Certs generated by X for others. (e.g. at circle X, X<<C>> X<<A>>) - CHILD
- A can acquire the following Certs from the directory to establish as certification to B

  X <<W>> W <<V>> V <<Y>> Y<<Z>>Z<<B>>

  (Try to get A's certificate)

Revocation of Certificates

- Reasons for revocation:
  - The users secret key is assumed to be compromised.
  - The user is no longer certified by this CA.
  - The CA's certificate is assumed to be compromised.
- Client's may keep a cache every time they check against the revocation list.
- X.509 has a new version 3 with some recommendations for improvement – read in your own time if interested

Obtaining a User's Certificate

- Characteristics of certificates generated by CA:
  - Any user with access to the public key of the CA can recover the user public key that was certified.
    - User can independently calculate hash, decrypt digital certificate using CA's public key, extract hash and compare if hashes match.
  - No party other than the CA can modify the certificate without this being detected.
- Certificates stored in a Directory server – not part of standard.

Acknowledgements

- Network Security Essentials: Stallings, Chapter 4 provided by Henric Johnson, Blekinge Institute of Technology, Sweden (Please refer to Section 4.3 and 4.4 from Staillings)

- Computer Networking A top-Down Approach: Jim Kurose and Keith Ross, chapter 8 (several lecture foils provided by authors)

- Optional read (Public Key Infrastructure X.509 (PKIX)) WG, RFC 4949 for how to setup PKI, management protocol …