UNIVERSITÄT DUISBURG ESSEN

Sicherheit in Kommunikationsnetzen
(Network Security)

Key Management

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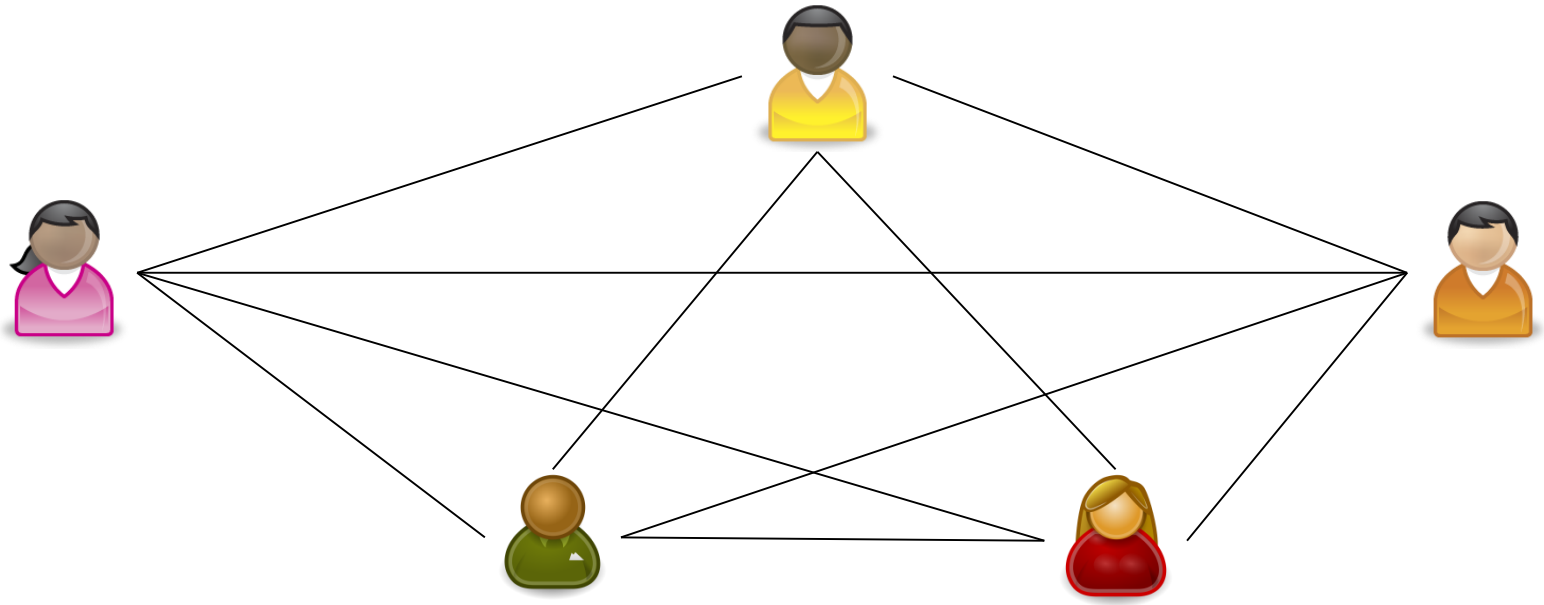
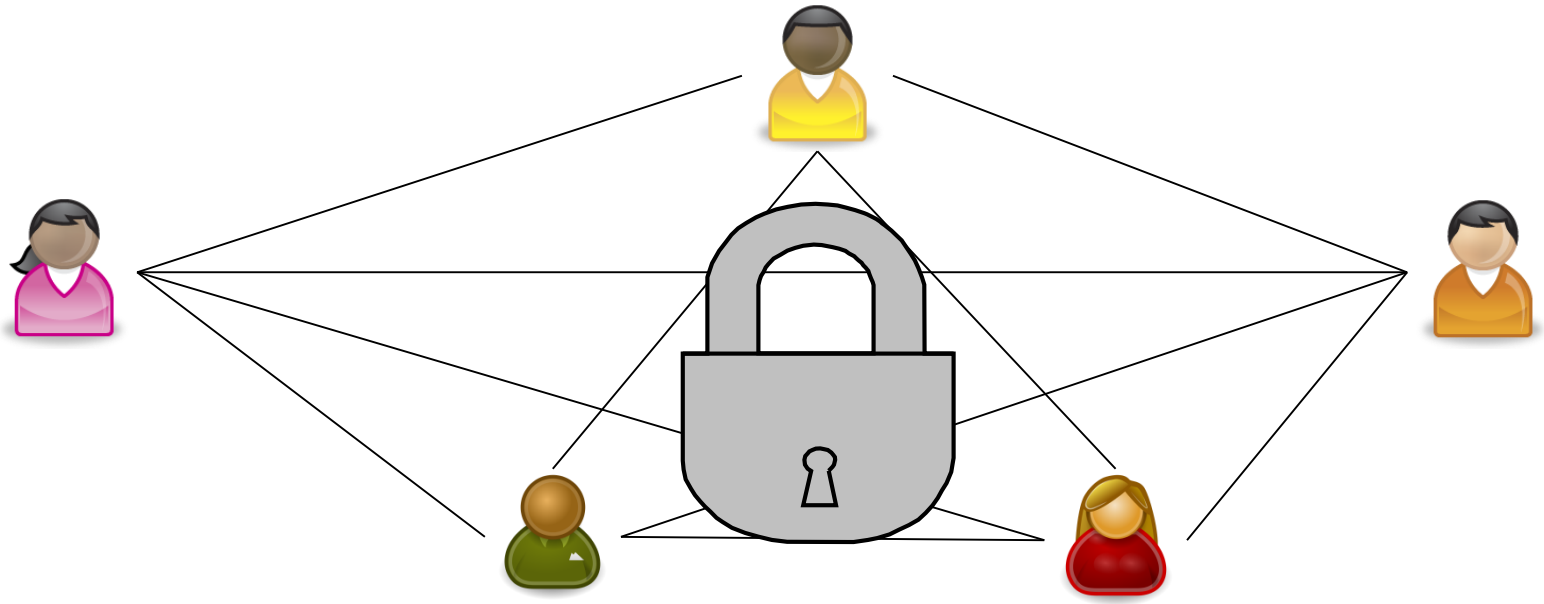
Symmetric Key Distribution

- How to negotiate secret keys between users?
  - Problem: scalability (one key for every pair of users)
  - Impractical with lots of users



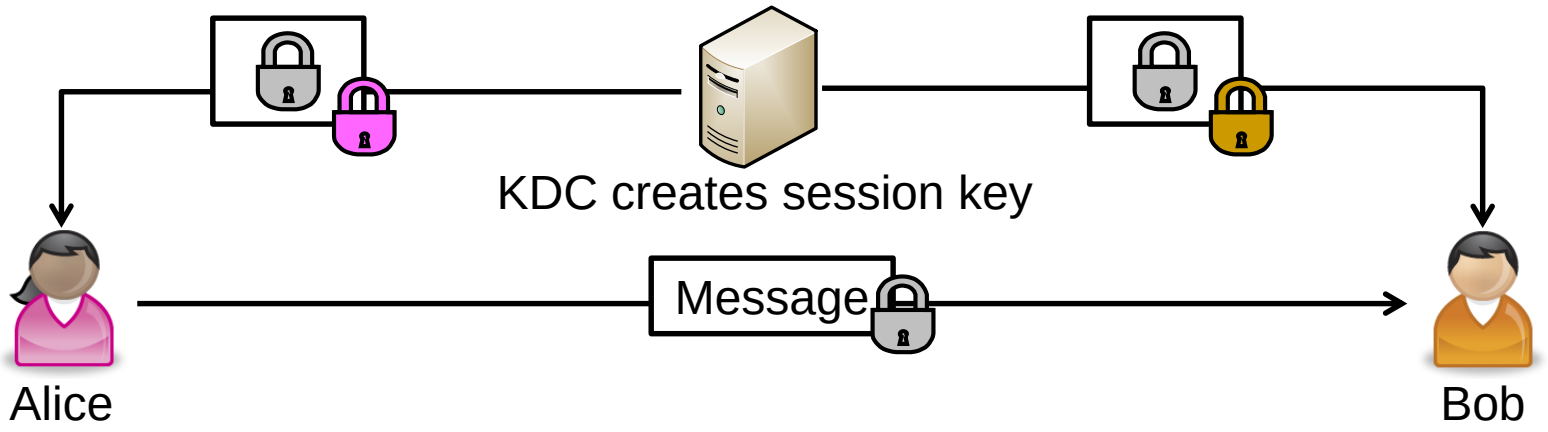
Group Key

- Idea: one group key
  - Adding new user: send key to new user
  - Remove user: re-distribute new group key
  - Each user is fully trusted, key disclosure fatal for all



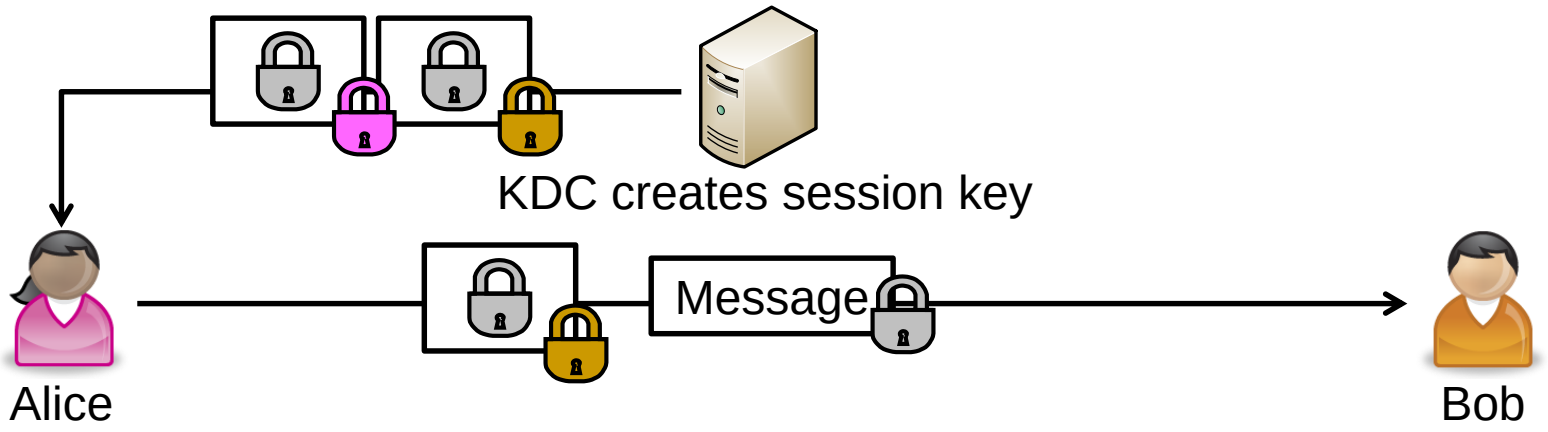
Key Distribution Center

- Idea: trusted key distribution center (KDC)
  - Negotiate master key between user and KDC
  - KDC creates on demand session key between Alice/Bob
  - Encrypt session key with Alice's key and Bob's key



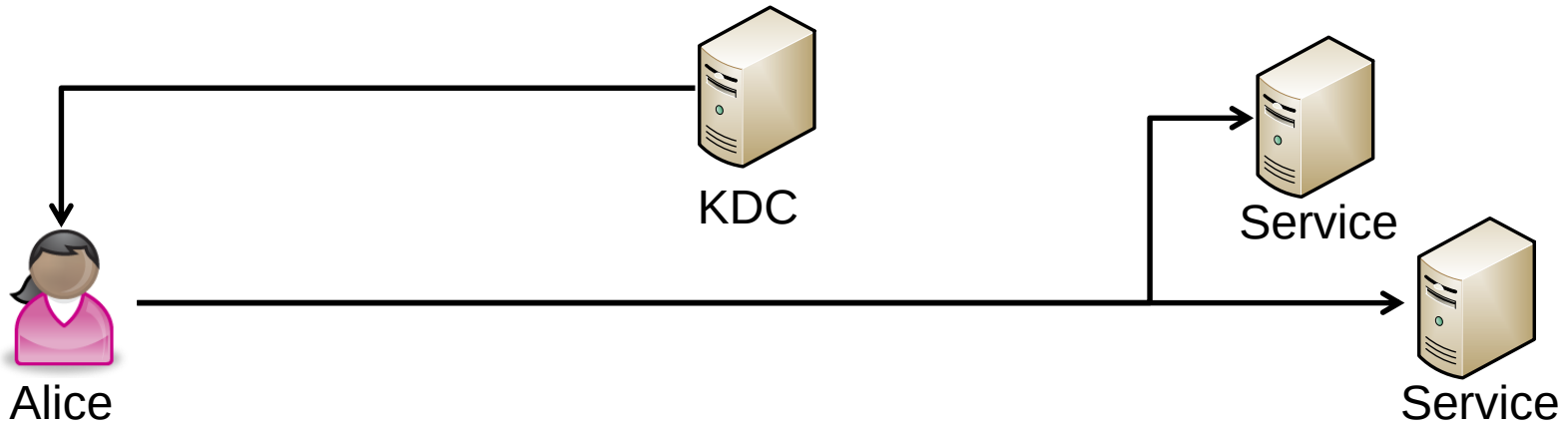
Key Distribution Center (2)

- KDC does not need to communicate with Bob
  - Piggyback session key for Bob over Alice‘s messages
- After key establishment, mutual authentication is needed
  - Prevent replay attacks with nonce and timestamp



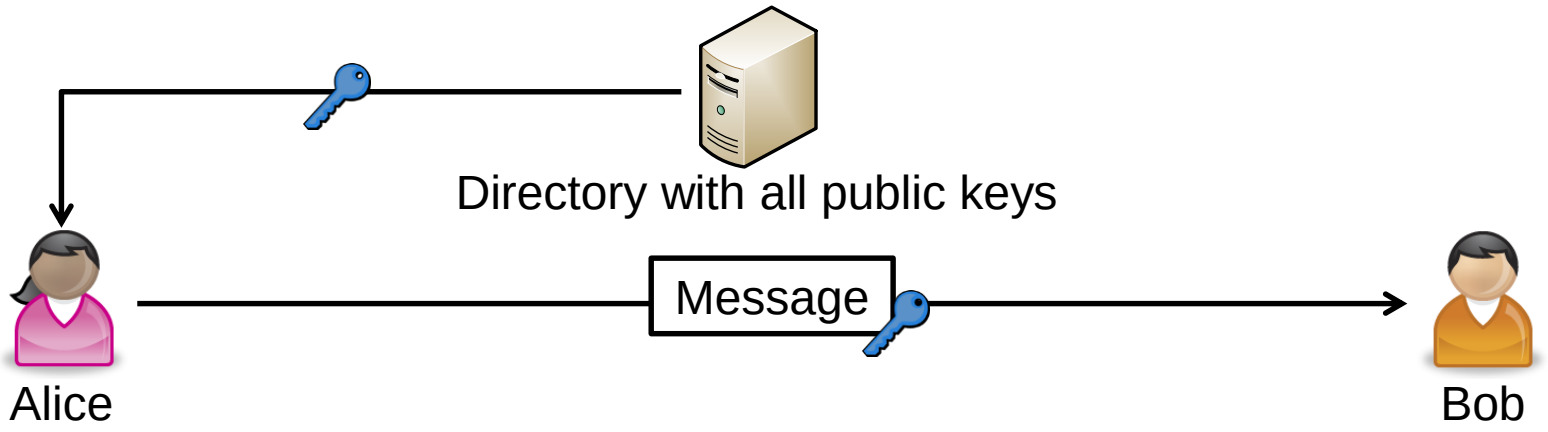
Key Distribution Center (3)

- With a KDC, we can implement authentication and authorization of users or clients
  - KDC checks: is the user allowed to access a service?
  - e.g. Kerberos: KDC creates session tickets
- Use case: single sign-on (centralized user login)



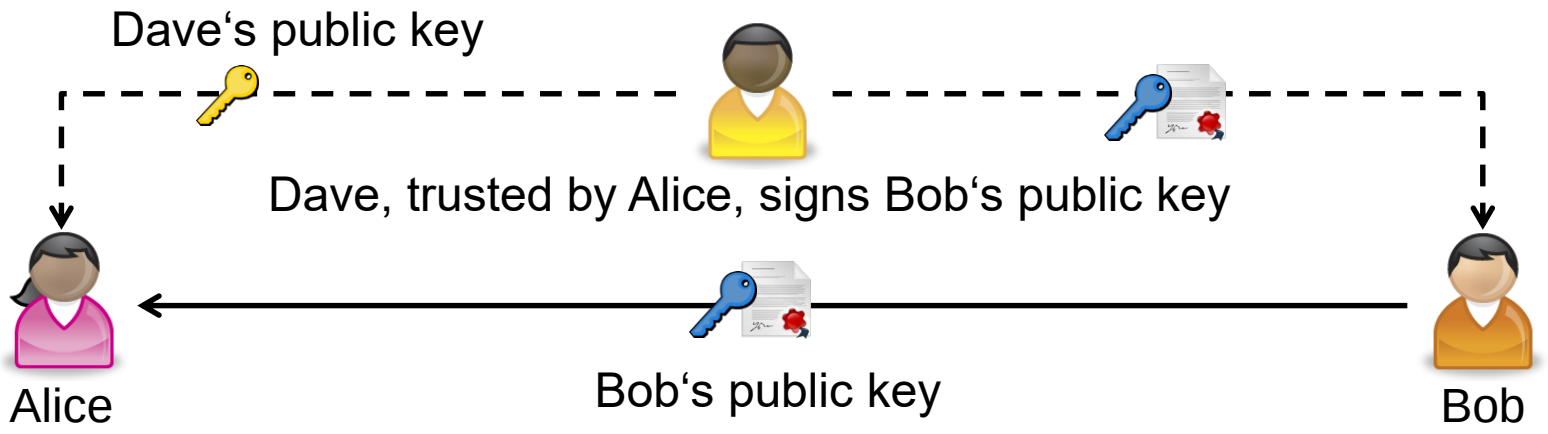
Public-Key Infrastructure

- Use a public-key infrastructure
  - Each user has a private/public key pair
- Problem: how to distribute public keys?
- Save public keys on a trusted directory server
  - Problem: bottleneck, scalability



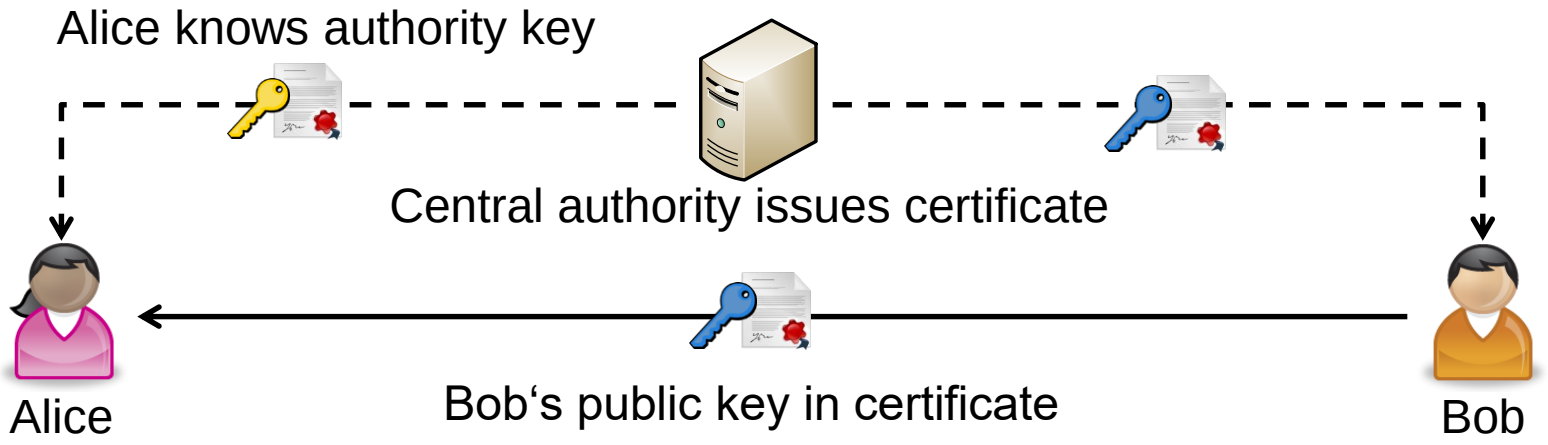
Public-Key Infrastructure (2)

- Distribute public keys directly between users
- How to authenticate public keys?
- Web of trust: transitive trust between users
  - Somebody you know attests the authenticity of somebody else and signs their public key



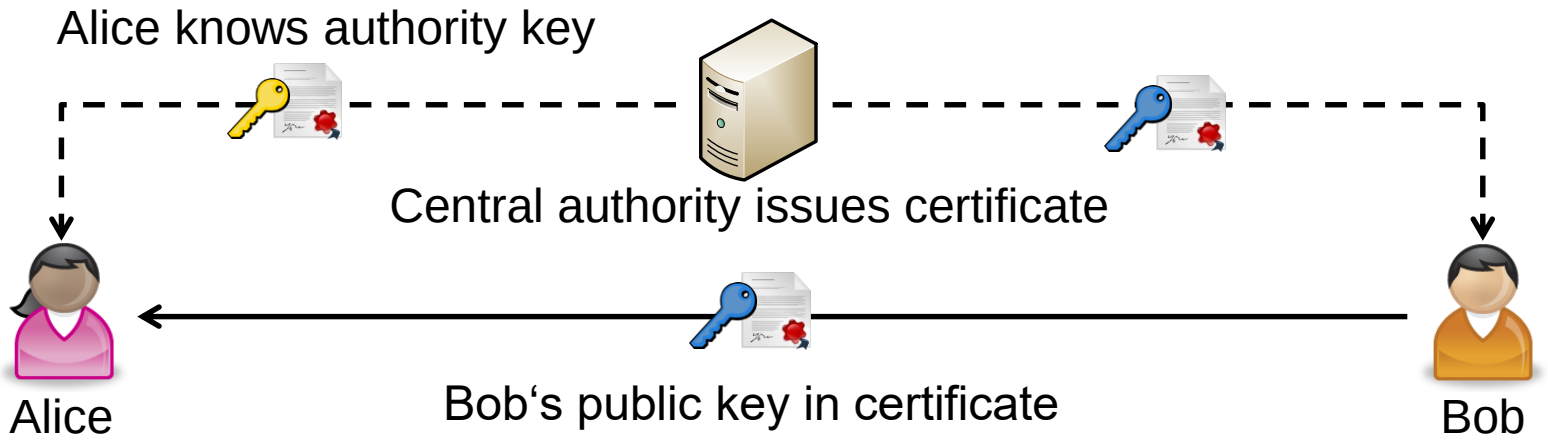
Public-Key Infrastructure (3)

- Authority: centralized trust
  - One (or a couple) of authorities attest the authenticity and sign public keys of all (or many) users
- Trusted authority issues certificate to Bob
  - Contains public key of Bob, signed by authority



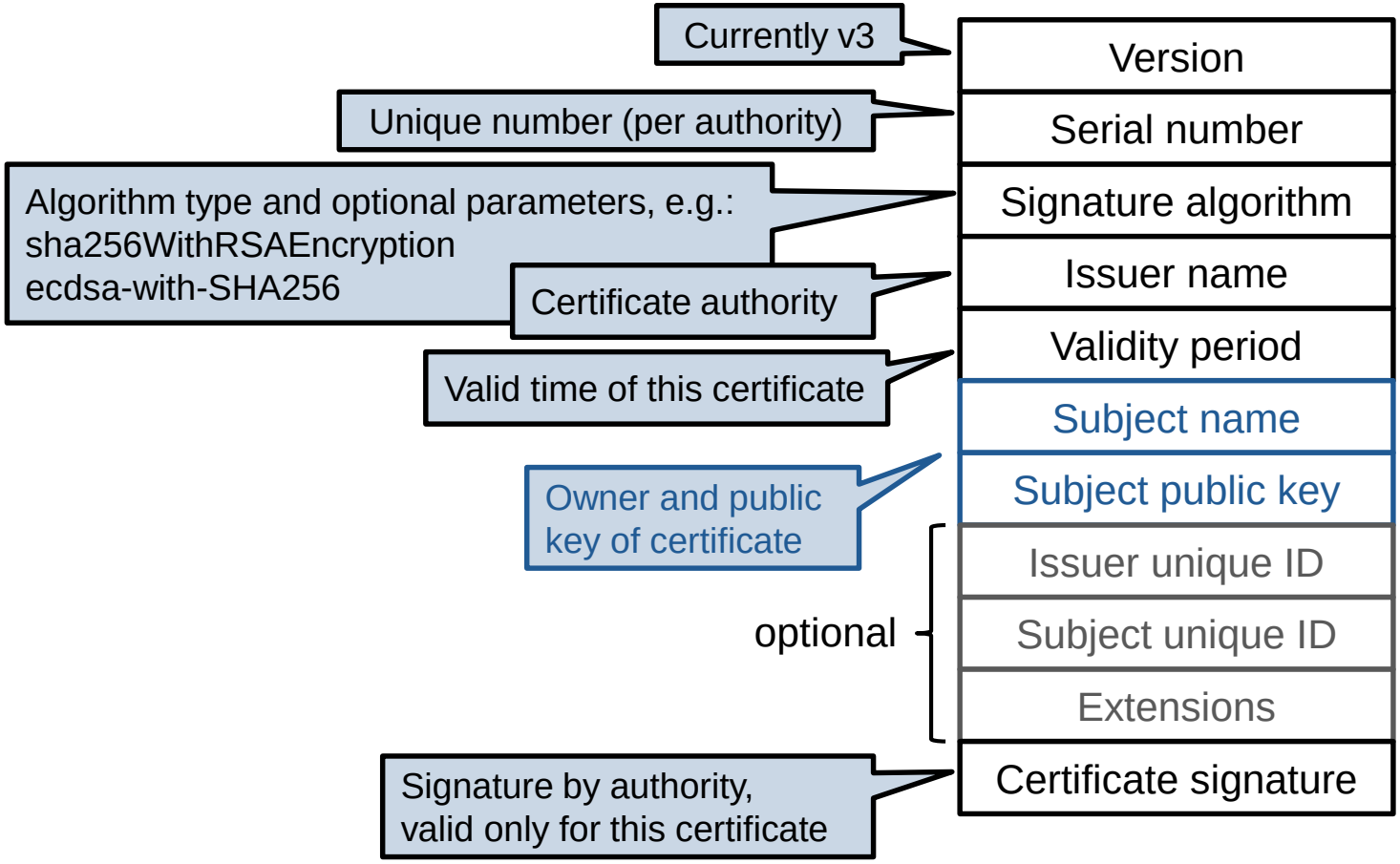
Public-Key Infrastructure (4)

- Alice has a list of trusted certificate authorities
- Certificates contain long-term keys
  - Bob‘s certificate is valid for months or years
- Benefit: little interaction with authority required

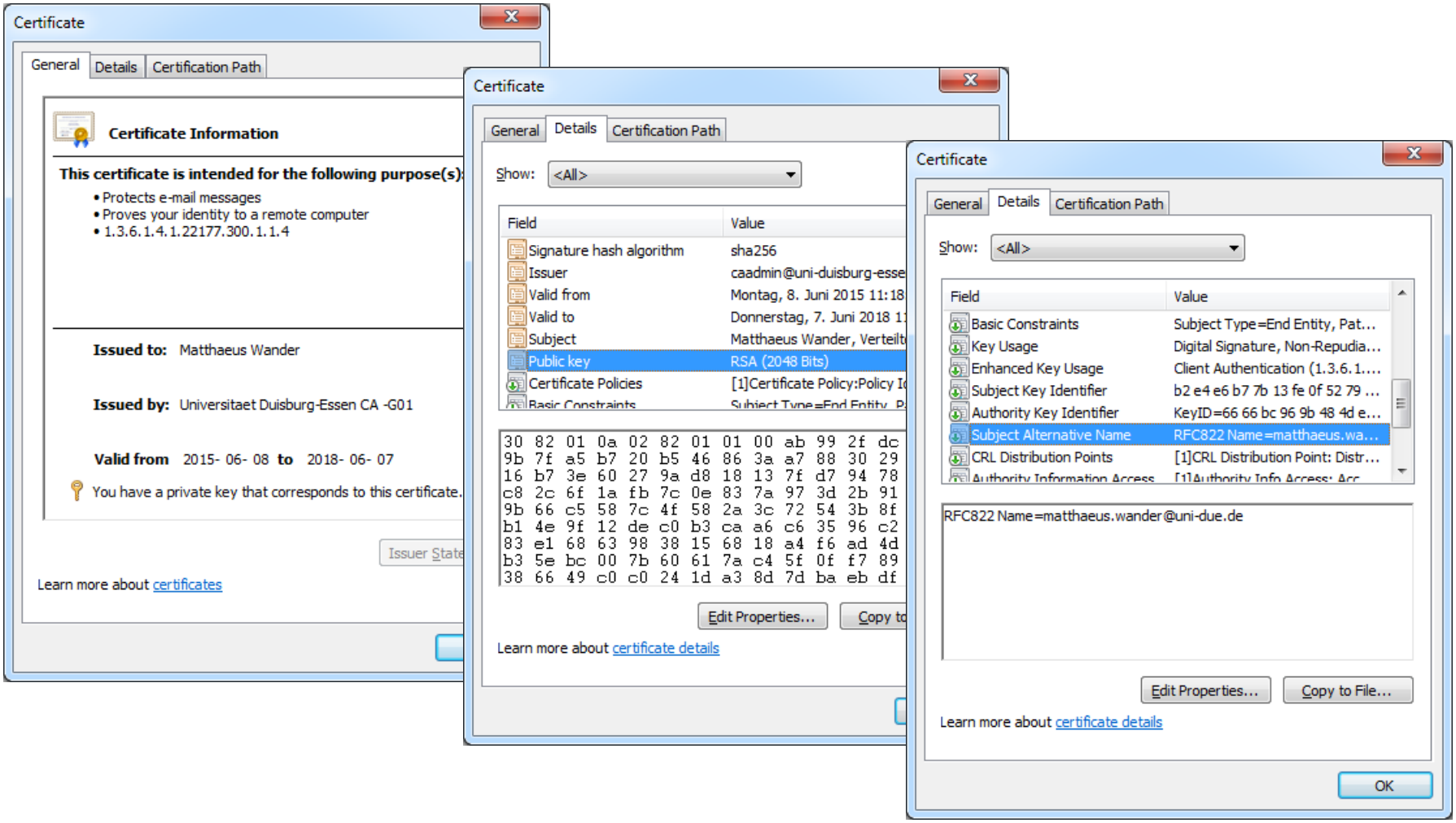


X.509

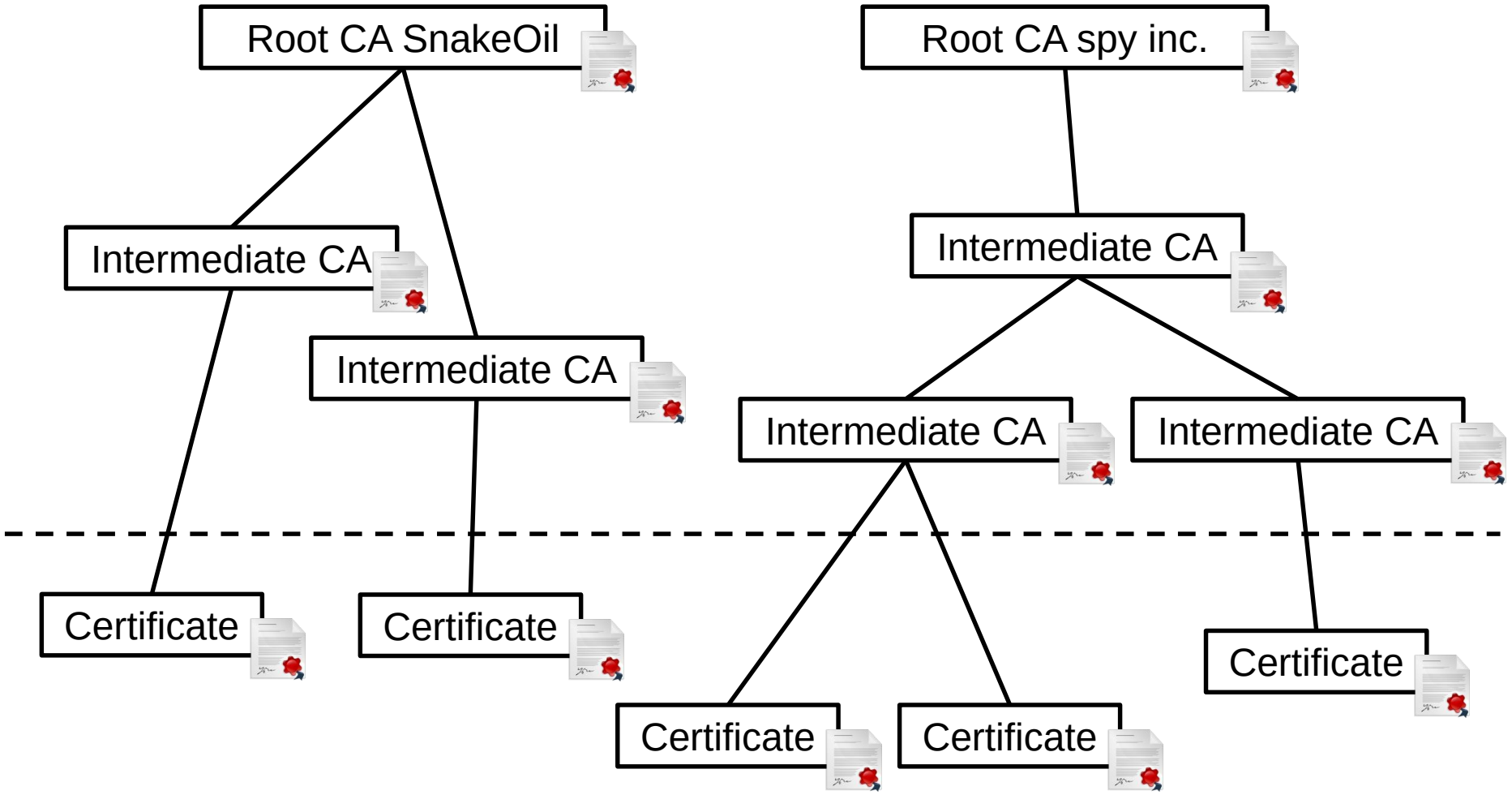
- X.509 is a standard for digital certificates



Example Certificate for Secure Email



X.509 Certificate Authorities



X.509 Certificate Authorities

- Hierarchy of certificate authorities (CAs)
  - Root CA certificates are installed on hosts
  - Root CA signs intermediate CA
  - Intermediate CA signs subject (e.g. user) certificate
- Each trusted CA (including intermediate) can issue certificate for any subject
  - With or without authorization of server owner
  - No transparency about issued certificates

(A few) Problems of X.509

- Name constraints suggested to restrict CAs
  - e.g. issue certificate only below *.domain.tld
  - Hardly supported by applications, i.e. ignored
- A few dozen root CAs shipped with operating system and applications (e.g. web browsers)
  - Managed primarily by vendors, not users
  - CAs occasionally get hacked (DigiNotar, StartCom, …) or ignore security policies (e.g. backdated certificates)
  - Withdrawing CA trust can impact thousands of users

Suggested Solutions for X.509

- Certificate Transparency for CAs
  - Standard for publishing a log of issued certificates
  - Log is cryptographically secured
  - Monitors and auditors check logs for correctness
- Certificate pinning in applications
  - Hard-coded public keys or certificates in applications
  - Application checks whether received certificate strictly matches hard-coded certificate
  - ... or whether it is issued by a hard-coded CA

Certificate Revocation

- In case of a security mishap, certificates can be revoked (declared as invalid)
  - Various problems in practice, revocation often ignored
- CA publishes Certificate Revocation List (CRL)
  - Flat list, does not scale
- Online Certificate Status Protocol (OCSP)
  - Check revocation status via network request to CA
  - Problems: reliability, downgrade attacks, privacy
  - Mitigated by OCSP stapling: server appends cached OCSP response to certificate

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Security Infrastructures

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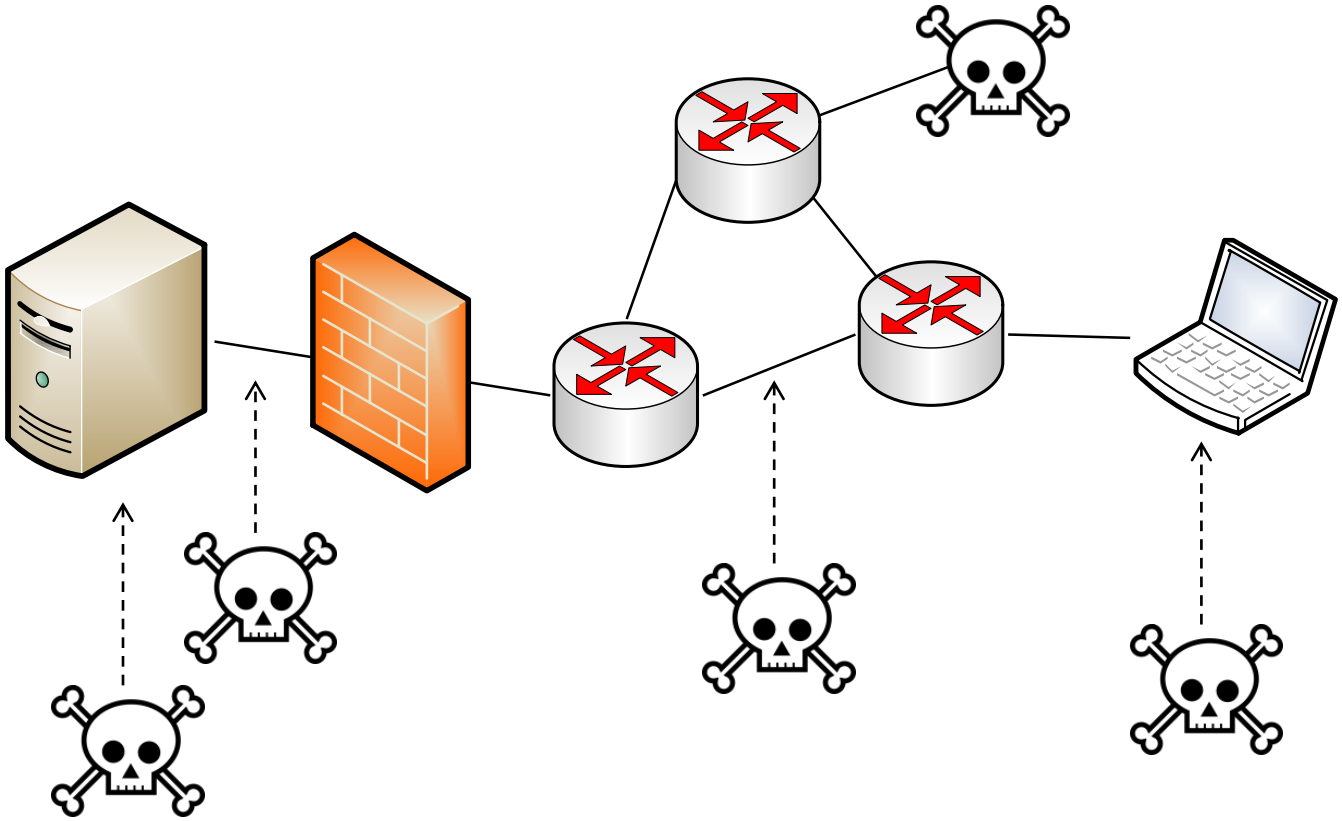
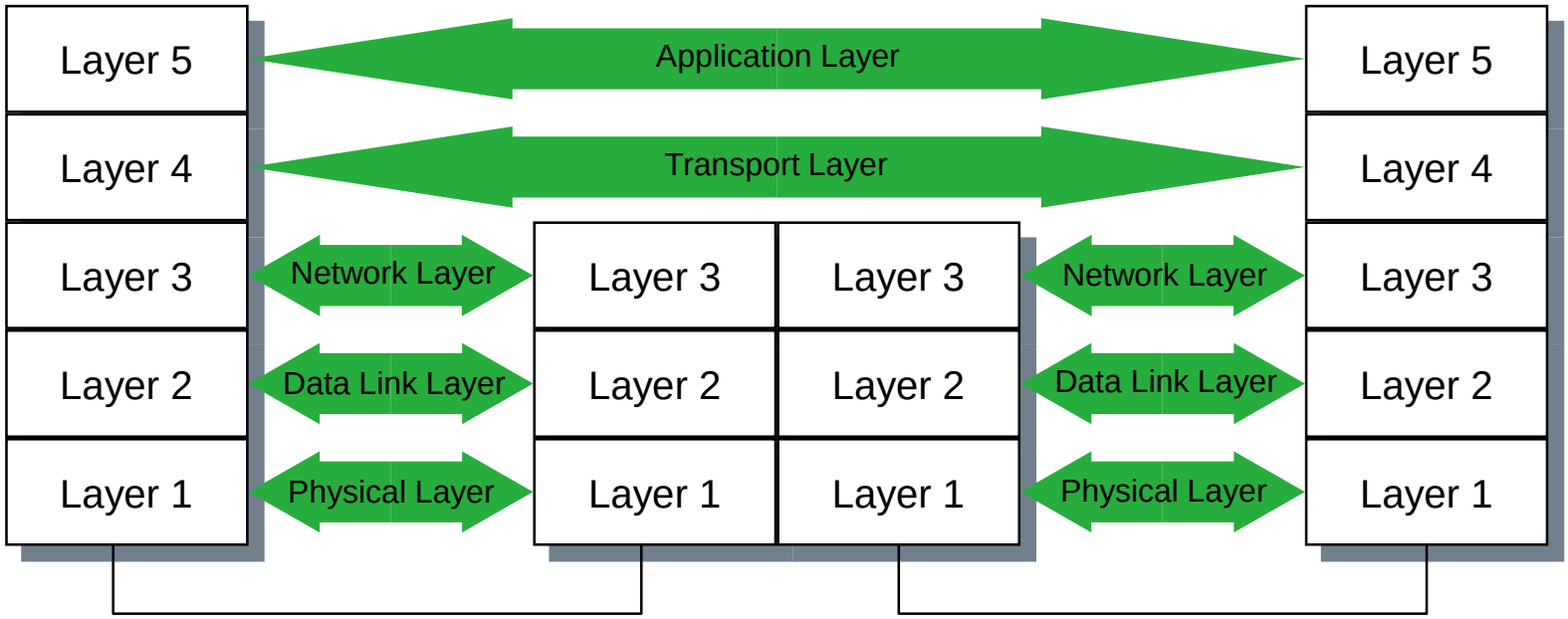
Threat Model

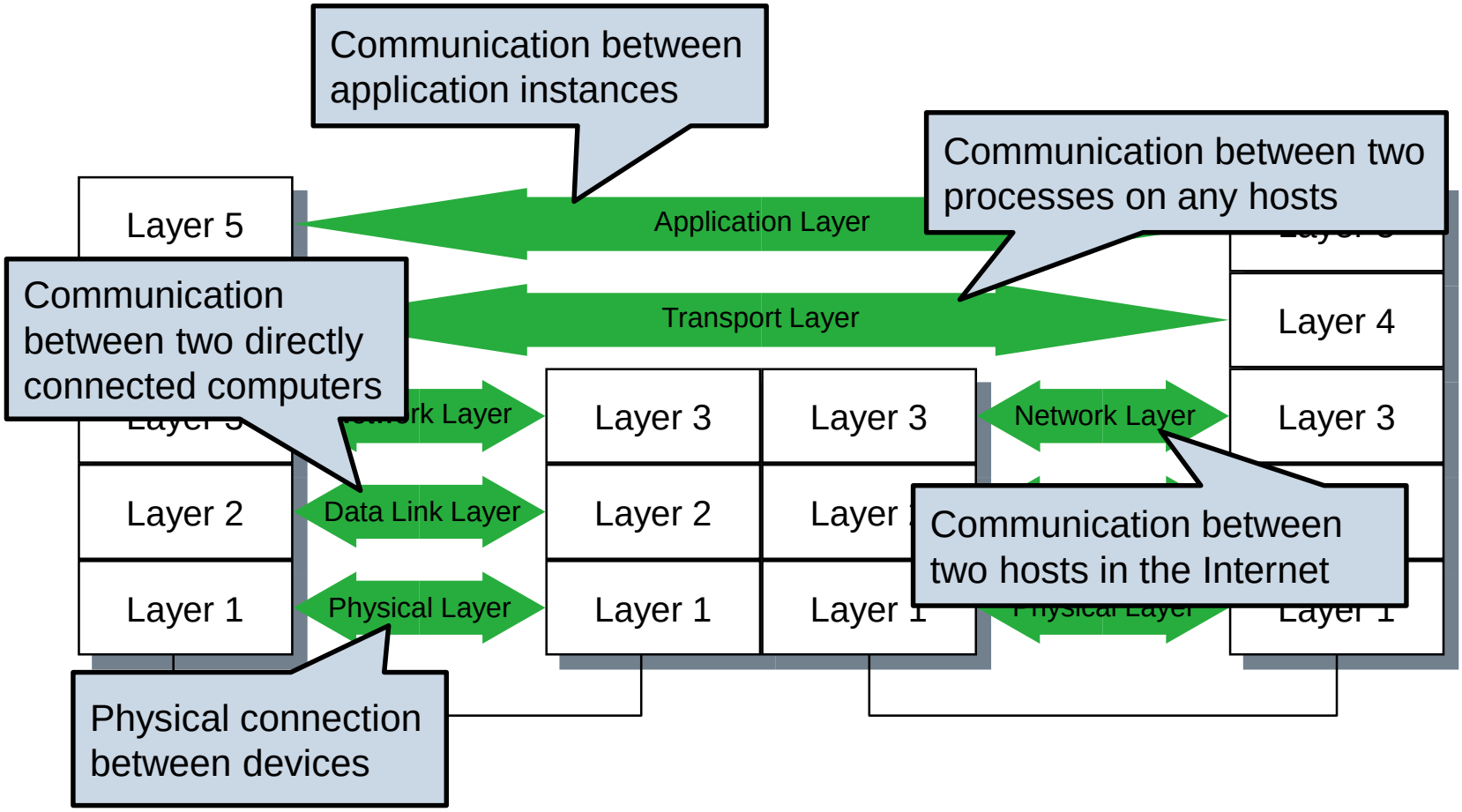
- Where is the attacker located?



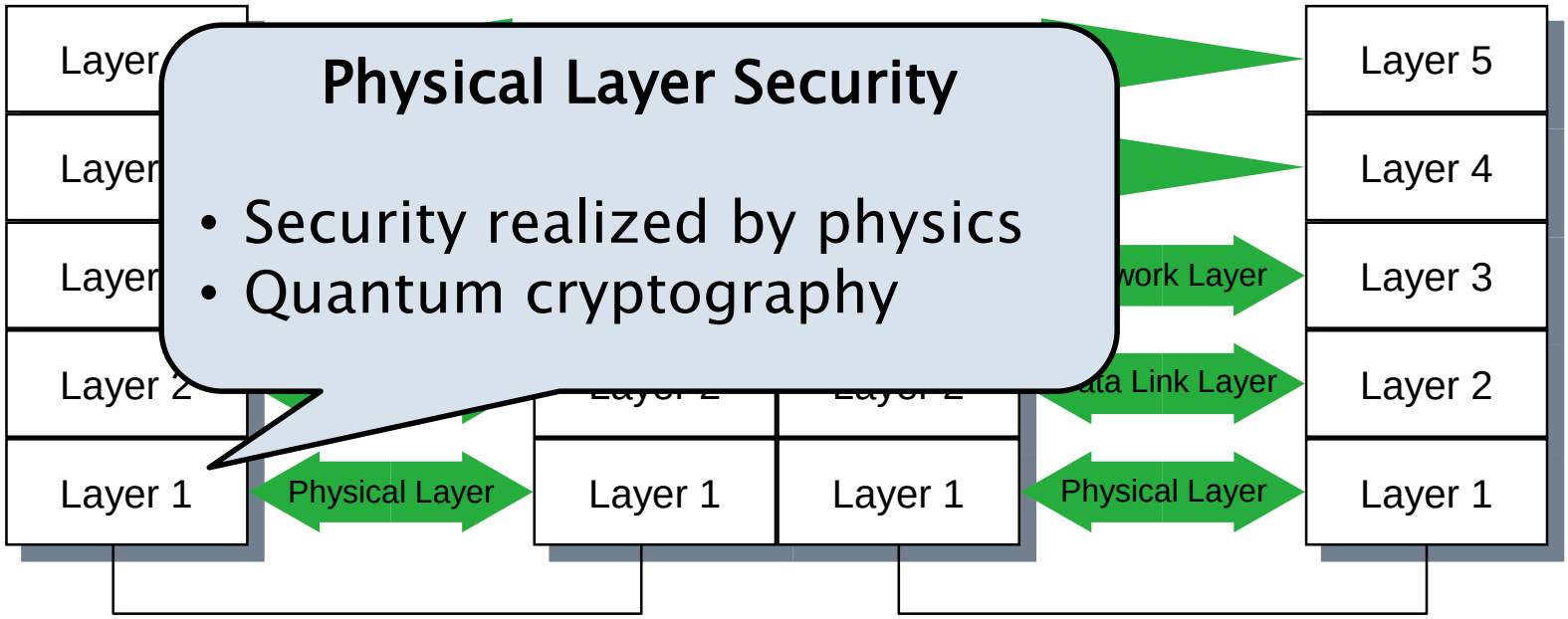
Protocol Layers



Protocol Layers (2)



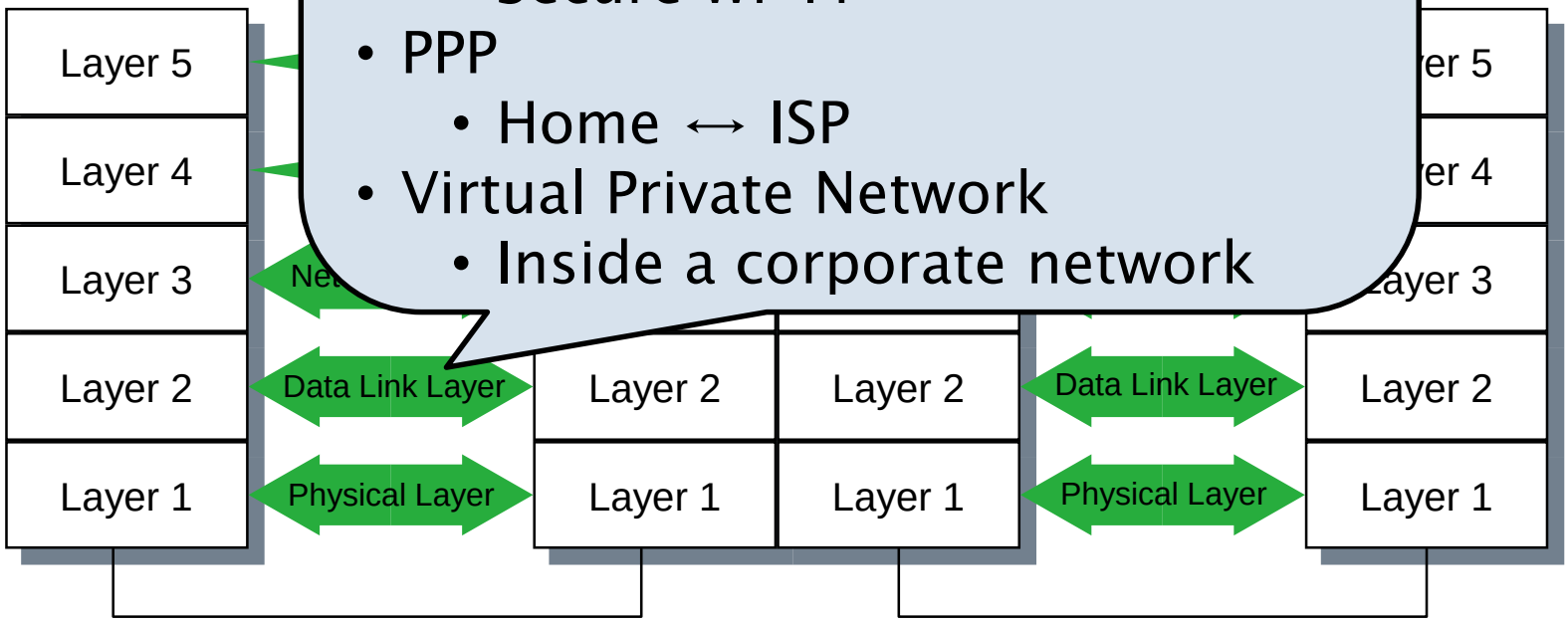
Protocol Layers (3)



Protocol L

Data-Link Layer Security

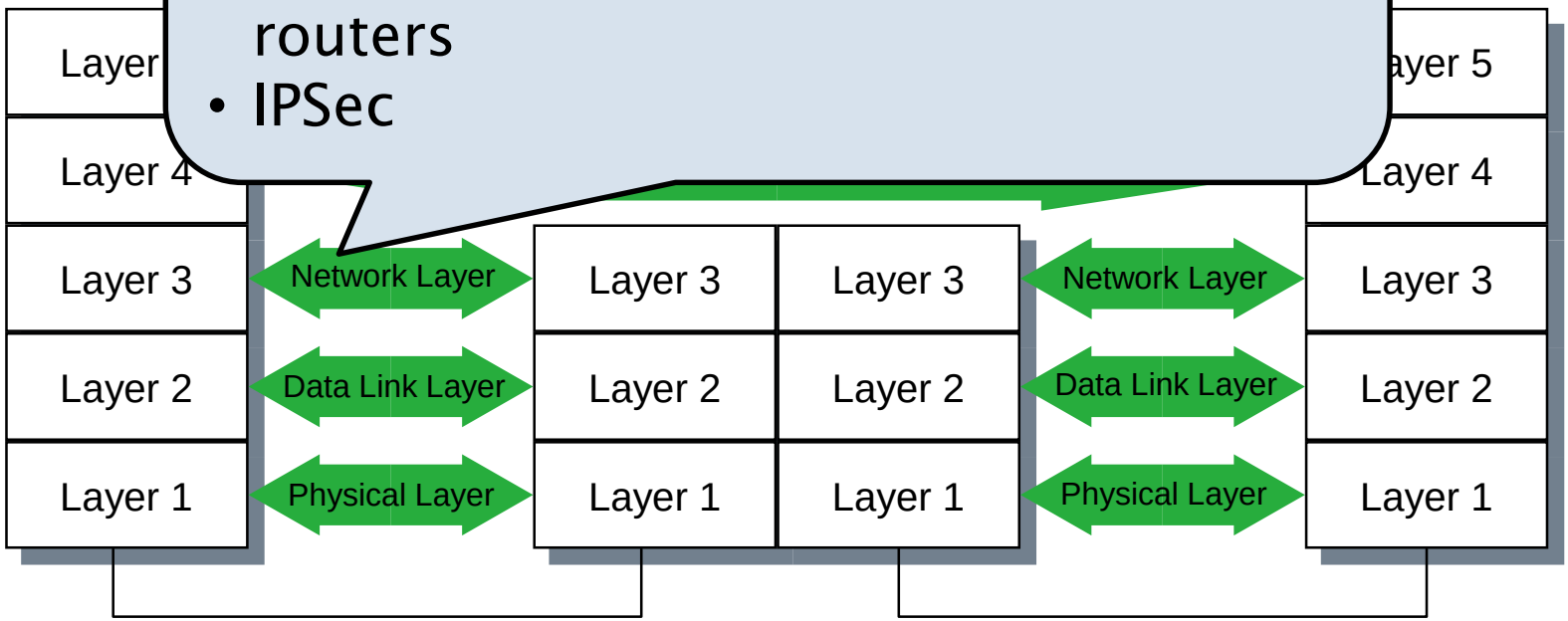
- Implemented by network interface cards, switches, etc.
- WPA2
  - Secure Wi-Fi
- PPP
  - Home ↔ ISP
- Virtual Private Network
  - Inside a corporate network



Protocol Layers (5)

Network Layer Security

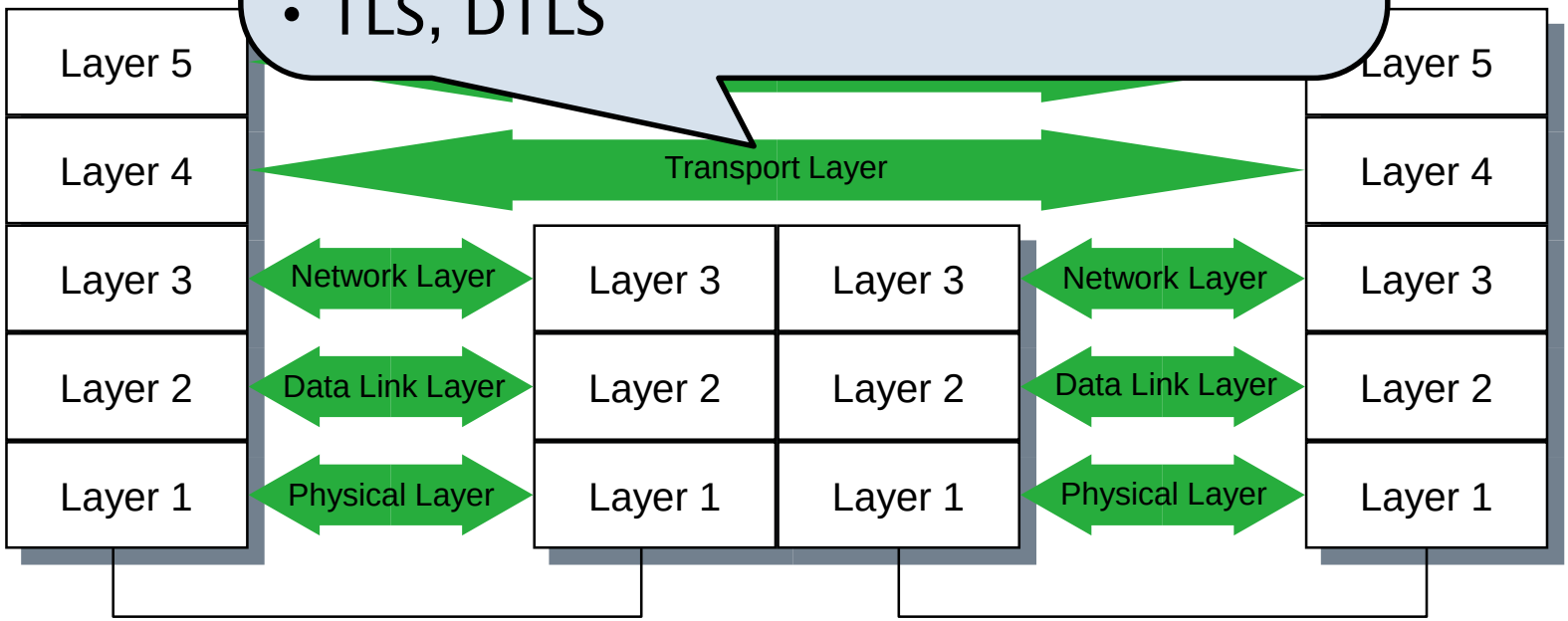
- Security on the IP packet level
- Implemented by operating system and routers
- IPSec



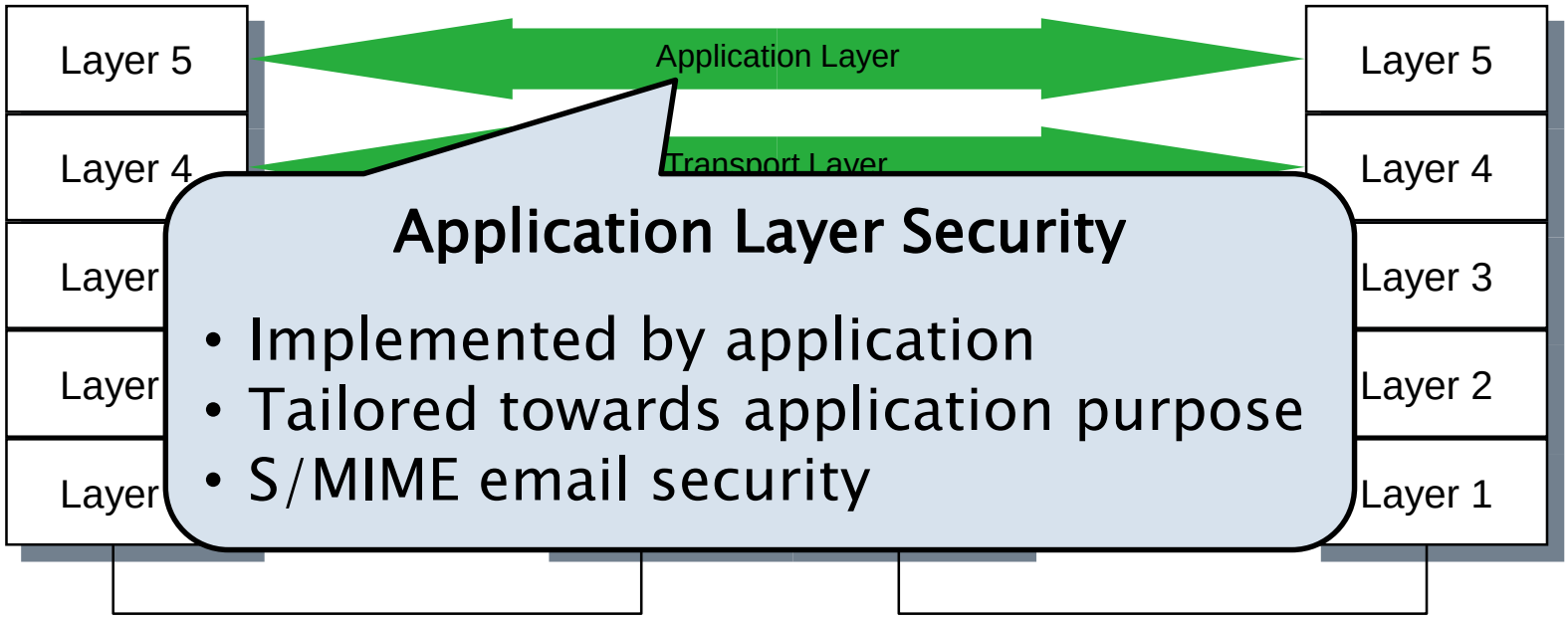
Protocol

Transport Layer Security

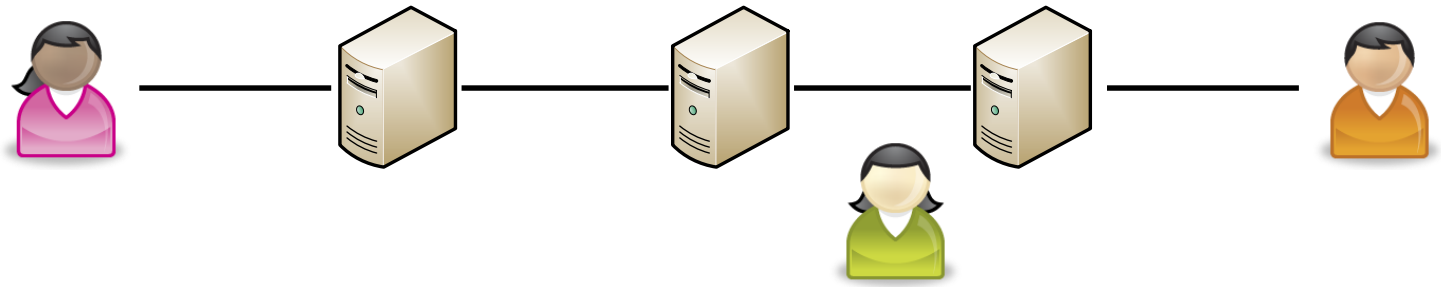
- Implemented by operating system or by application
- Works on top of Sockets
- TLS, DTLS



Protocol Layers (7)

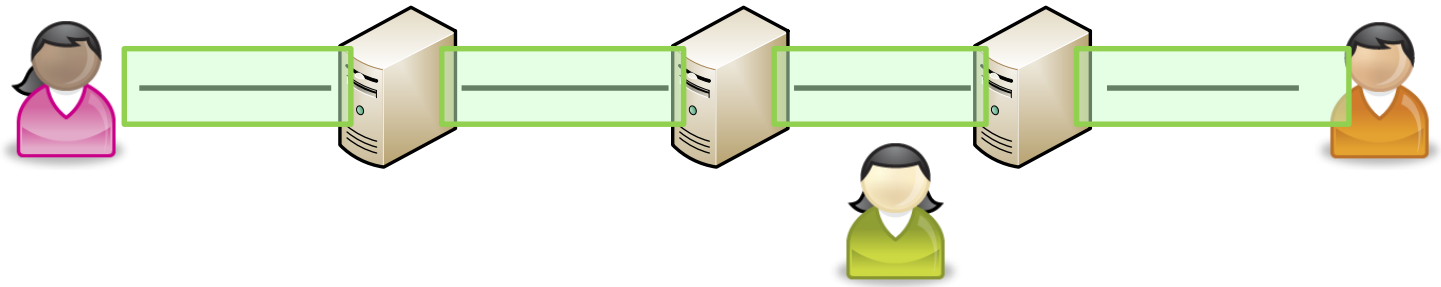


System Model



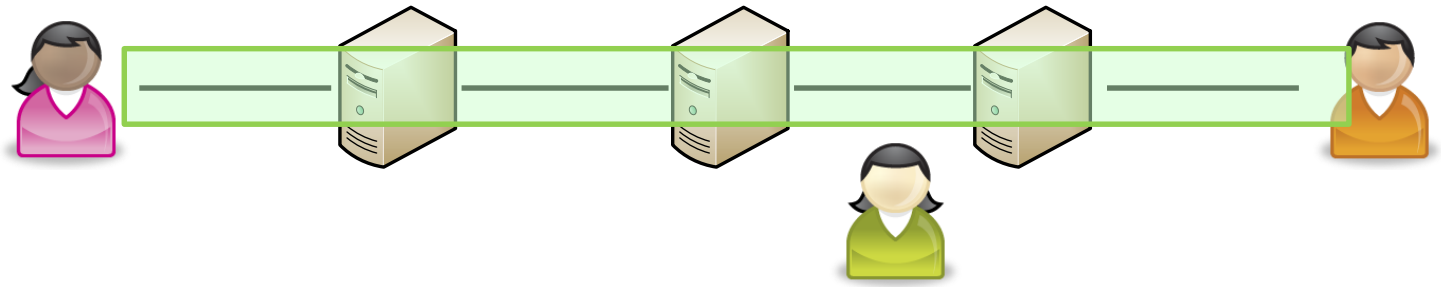
- Who talks with whom?
- Who is trusted?
- Who needs access to which data?
  - Are the servers only for storage and communication?
  - Or also for processing of our data?

System Model (2)



- Point-to-point security
  - Secures communication link between two components
  - Each component is trusted to comply with security
  - Servers process plaintext messages
  - In multi-hop communication, each link is independent from the others (but all of them need to be secure!)

System Model (3)



- End-to-end security
  - Secures communication between two endpoints
  - Only endpoints are trusted to comply with security
  - Servers forward secure messages and see metadata, but cannot tamper nor assist with the contents
  - Usually harder to achieve than point-to-point security