Energy Informatics

04 Security

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What is a Threat

- Definition
  - A threat of a computer network is any possible event or series of actions that can lead to a breach of security objectives
  - The realization of a threat is an attack
- Examples
  - A hacker gains access to a closed network
  - Publication of passing e-mails
  - Unauthorized access to an online bank account
  - A hacker brings a system to crash
  - Identity theft

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Security Objective

- Confidentiality
  - transmitted or stored data can only be read or written from the target audience
- Anonymity
  - confidentiality of the identity of the participants
- Data integrity
  - changes of data should be avoided
  - author of data should be visible
- Accountability
  - for each communication event the responsible person should be detectable
- Availability
  - services should be available and operating
- Access control
  - Services and information should be accessible only to authorized users

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Threats

- Masquerade
  - somebody pretends to be someone else
- Eavesdropping
  - someone reads information that is not for him
- Authorization Violation
  - someone uses a service or a resource that is not allowed for him
- Loss or alteration of information
  - data is altered or destroyed
- Denial of communication
  - Someone claims not to be in responsible for the ongoing communication
- Falsifying information
  - Someone created or changed messages on behalf of other
- Sabotage
  - Every action restricting the availability or proper functioning of the services or the system

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Threats and Security Goals

Security Objective	Threat						
	Masquerade	Eavesdropping	Authorization Violation	Loss or Alteration of Information	Denial of Communication	Falsifying Information	Sabotage
Confidentiality	X	X	X				
Anonymity	X		X	X		(X)	
Accountability	X		X		X	X	
Availability	X		X	X			X
Access Control	X		X			X	

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Terminology of Communication Security

- Security service
  - An abstract service that tries to achieve a security feature
  - can be realized with (or without) the help of cryptographic algorithms and protocols, e.g.
    - encryption of data on a hard disk
    - CD in a safe
- A cryptographic algorithm
  - mathematical transformations
  - used in cryptographic protocols
- A cryptographic protocol
  - Series of steps and messages to achieve a security goal

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Security Service

- Authentication
  - Digital Signature: data is provable received from the author
- Integrity
  - secures that a date is not modified without detection
- Confidentiality
  - data can only be understood by the recipient
- Access control
  - check that only authorized persons have access to services and information
- Repudiation
  - proves that the message is undeniably from the originator

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Encryption Methods

- Symmetric encryption algorithms, e.g.
  - Feistel cipher
  - DES (Digital Encryption Standard)
  - AES (Advanced Encryption Standard)
- Cryptographic hash function
  - SHA-1, SHA-2
  - MD5
- Asymmetric encryption
  - RSA (Rivest, Shamir, Adleman)
  - El-Gamal
- Digital signatures (electronic signatures)
  - PGP (Phil Zimmermann), RSA

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Symmetric Encryption

- E.g. Caesar's code, DES, AES
- Functions f and g, where
  - Encryption f
    - f (key, text) = code
  - Decoding g:
    - g (key, code) = text
- The key
  - must remain secret
  - must be available to the sender and receiver

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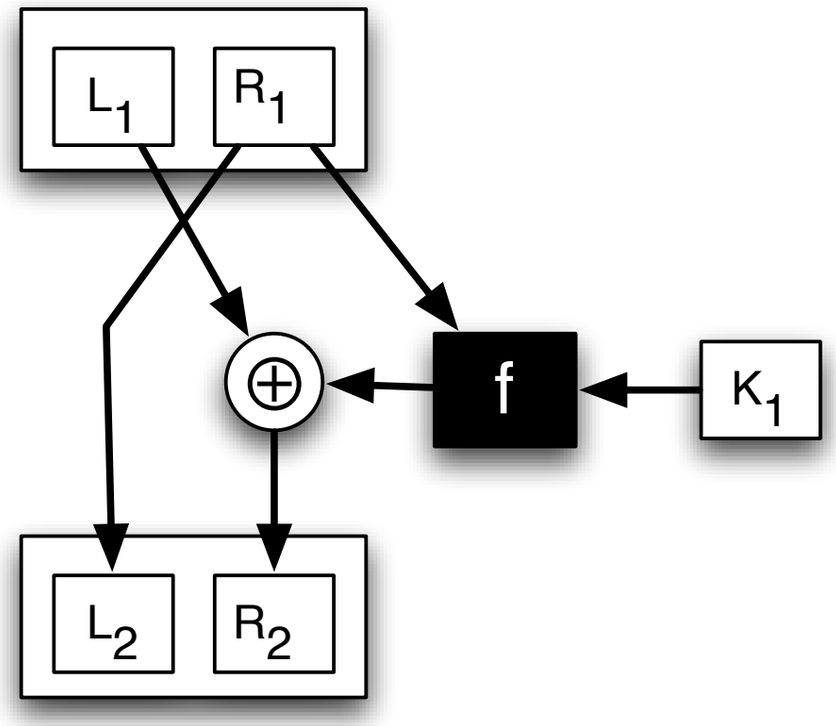
Feistel Chiffre

- Splitting the message into two halves L_1, R_1
  - Keys K_1, K_2, ...
  - Several rounds: Resulting code: L_n, R_n
- encoding
  - $L_i = R_{i-1}$
  - $R_i = L_{i-1} \oplus f(R_{i-1}, K_i)$
- Decryption
  - $R_{i-1} = Li$
  - $L_{i-1} = R_i \oplus f(L_i, K_i)$
- f may be any complex function



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Other Symmetric Codes

- Skipjack
  - 80-bit symmetric code
  - is based on Feistel Cipher
  - low security
- RC5
  - 1-2048 bits key length
  - Rivest code 5 (1994)
  - Several rounds of the Feistel cipher

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Digital Encryption Standard

- Carefully selected combination of
  - Xor operations
  - Feistel cipher
  - permutations
  - table lookups
  - used 56-bit key
- 1975 developed at IBM
  - Now no longer secure
  - more powerful computers
  - New knowledge in cryptology
- Succeeded by: AES (2001)

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Advanced Encryption Standard

- Carefully selected combination of
  - Xor operations
  - permutations
  - table lookups
  - multiplication in GF [2^8]
  - 128, 192 or 256-bit symmetric key
- Joan Daemen and Vincent Rijmen
  - 2001 were selected as AES, among many
  - still considered secure

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Cryptographic Hash Function

- E.g. SHA-1, SHA-2, MD5
- A cryptographic hash function h maps a text to a fixed-length code, so that
  - h(text) = code
  - it is impossible to find another text:
    - h(text‘) = h(text) and text ≠ text'
- Possible solution:
  - Using a symmetric cipher

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Asymmetric Encryption

- E.g. RSA, Ronald Rivest, Adi Shamir, Lenard Adleman, 1977
  - Diffie-Hellman, PGP
- Secret key: s_k
  - Only the receivers of the message know the secret key
- Public key: p_k
  - All participants know this key
- Generated by
  - keygen(sk) = pk
- Encryption function f and decryption function g
  - Known to everybody
- Encryption
  - f(pk,text) = code
  - everybody can generate code
- Decryption
  - g(sk,code) = code
  - only possibly by receiver

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Example: RSA

- R. Rivest, A. Shamir, L. Adleman
  - On Digital Signatures and Public Key Cryptosystems, Communication of the ACM
- Algorithm is based on the computational complexity of integer factorization
- 1st example
  - 15 = ? * ?
  - 15 = 3 * 5
- 2nd example
  - 3865818645841127319129567277348359557447904102899335864835520474 43 = 12345678901234567890123456789002 09 * 3131313131313131313131313131300227
- To this day no efficient integer factorization algorithm is known
  - Multiplication can be done efficiently
  - Prime numbers can be found efficiently
    - Since prime numbers occur frequently
    - Efficient randomized prime number tests are available

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RSA

- Generation of keys
  - Choose two random prime numbers p, q with k bits (k ≥ 500).
  - n = p·q
  - e is a number relatively prime to (p - 1)·(q - 1).
  - $d = e^{-1} \bmod (p - 1)(q - 1)$
    - i.e. $d \cdot e \equiv 1 \bmod (p - 1)(q - 1)$
- Public key pk = (e, n)
- Secret key sk = (d, n)
- Encoding
  - Partition message in block sizes of 2^k bits
  - Interprete block M as number $0 \leq M < 2^{2k}$
  - Code: $P(M) = M^e \bmod n$
- Decoding
  - $S(C) = C^d \bmod n$

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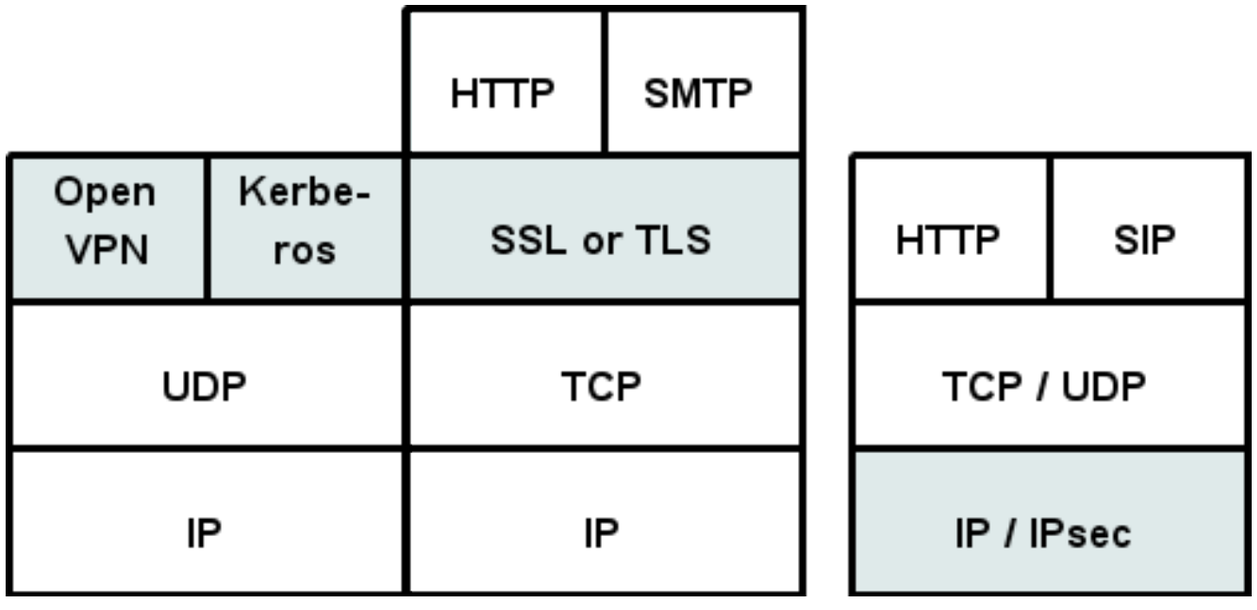
Digital Signatures

- Digital Signatures
  - signer has a secret key **sk**
  - document will be signed with the secret key
  - and can be verified with a public key **pk**
  - public key is known to all
- Example of a signature scheme
  - m: message
  - Signer
    - computes **h(text)** with cryptographic hash function **h**
    - and publishes m and
      signature = g (sk, h (text)),
      g is the decryption function
  - Checker
    - computes h(text)
    - and verifies
      f (pk, signature) = h (text)
      for the asymmetric encryption function **f**

Network Security on Different Layers

- Security measures could be hooked to different layers of the stack
  - Link layer: one `hop` (e.g. wireless link)
  - IP Layer (IP-Sec): transparent to application
  - Transport Layer (SSL/TLS): easy, widely used
  - Application Layer (PGP, S/MIME)



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SSL (Secure Socket Layer)

- Transport layer security service, yields secure channel
  - Secure byte stream
  - Optional public-key server authentication
  - Optional client authentication
- Development started by Netscape to offer secure Internet business
  - Used/Implemented with HTTP first (HTTPS, port 443)
  - Hash: combined MD5 & SHA
  - Encryption: Diffie Helman, RSA & DES, RC4
- Version 3 designed with public input; subsequently became Internet standard TLS (Transport Layer Security)
- Uses TCP to provide a reliable end-to-end service
  - Not restricted for secure web (HTTP) transactions
  - Useful for any TCP based service to be secured: HTTP, IMAP, POP, NNTP, telnet, telephony signaling

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OpenVPN

- Networking
  - uses UDP
  - creates SSL tunnel
  - Point to point
- Encryption
  - OpenSSL library with RSA, AES, RC5, MD4, SHA-2, …
- Authentication by
  - pre-shared keys
  - certificates
  - user/password

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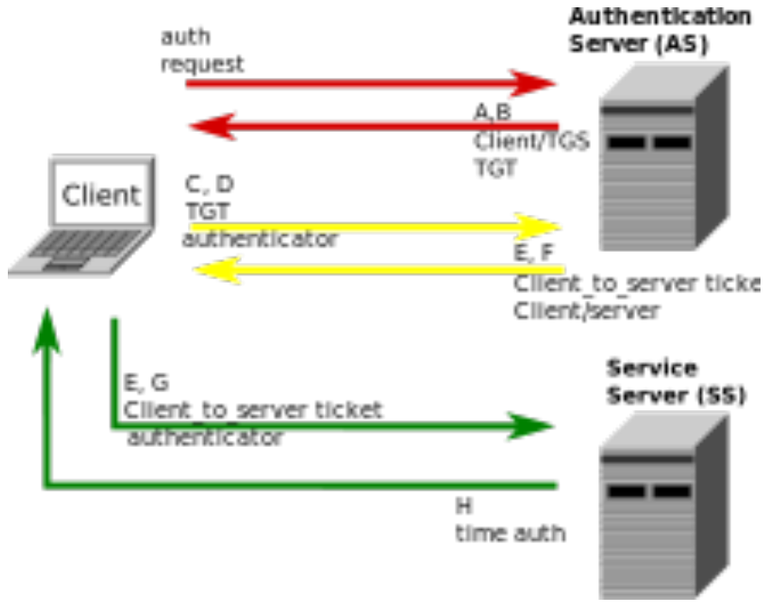
Kerberos

- Authenticates
  - servers and client
  - protects against eavesdropping and replay attacks
- Networking
  - uses authentication server (AS)
  - client authenticates to the AS
    - via UDP
  - receives a ticket to connect to the service
- Encryption methods
  - DES, AES for communication
  - Public key during authentication (optionally)



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IP sec

- IP level security -> IPsec
- IPSEC is Internet Protocol SECurity
  - above the network layer
  - no alteration to the IP was needed
  - simply the transportation protocol was interchanged (or and additional security header introduced)
- Strong cryptography
  - Authentication ensures that packets are from the right sender and have not been altered in transit
  - Encryption prevents unauthorized reading of packet contents

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IPsec

- IPSEC: framework for encrypting the whole IP traffic that might occur
- In reality: mainly secure tunnels through untrusted networks
  - Every packet passing through the untrusted net
  - encrypted by the IPSEC gateway machine
  - decrypted by the gateway at the other end
- Another implementation of a Virtual Private Network (VPN)
  - Seen OpenVPN in practical as another example

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