



Network Security IN2101

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- ❑ Studium Elektrotechnik, Universität Stuttgart
- ❑ Master of Science in Digital Systems, Brunel University, London, U.K.
(Master Thesis bei General Electric Corporation, Hirst Research Centre, London)
- ❑ Projekt bei Telecom Paris - Ecole Nationale Supérieure des Télécommunications (ENST), Paris
- ❑ Promotion in Informatik an der Universität Karlsruhe, am Institut für Telematik; Stipendium im Graduiertenkolleg 'Beherrschbarkeit komplexer Systeme'
- ❑ Postdoktorand am Institut Eurecom, Sophia Antipolis, France
- ❑ Fraunhofer Institut FOKUS (GMD FOKUS), Berlin
Leiter des Competence Center Global Networking
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- ❑ Seit 1. April 2008: Lehrstuhl für Netzarchitekturen und Netzdienste, TU München



Network Security

Chapter 1 Introduction



Course organization

- ❑ Lecture
 - Tuesday, 16:15-17.45, MI 00.08.038
 - Bi-weekly Wednesday, 16:15-17.45, MI 00.08.038
- ❑ Exercises
 - Typically Bi-weekly Wednesday 16:15-17.45, MI 00.08.038
- ❑ Students are requested to subscribe to lecture and exercises at <http://www.net.in.tum.de/de/lehre/ws0809/vorlesungen/network-security/>
- ❑ Email list
 - for subscribers to lecture and exercises
- ❑ Questions and Answers / Office hours
 - Prof. Dr. Georg Carle, carle@net.in.tum.de
 - After the course and upon appointment
 - Dipl.-Inform. Ali Fessi, fessi@in.tum.de
- ❑ Course Material
 - All slides are available online. Slides may be updated during the course.
 - This course is based to a significant extend on slides provided by Prof. Günter Schäfer, author of the book "**Netzicherheit - Algorithmische Grundlagen und Protokolle**" by Günter Schäfer, available in German from **dpunkt Verlag**. (An English version is also available.) We gratefully acknowledge his support.



Fragen

- ❑ Wer studiert was?
 - Bachelor Informatik? / Wirtschaftsinformatik?
 - Master Informatik? / Wirtschaftsinformatik?
 - Diplom?
- ❑ Welche Vorkenntnisse?
 - Grundlagen Rechnernetze und Verteilte Systeme?
 - Was noch?
 - Kryptografie etc?
- ❑ Wer will an den Übungen teilnehmen?



Chapter 1

Introduction

- ❑ Motivation
- ❑ Threats in communication networks
- ❑ Security goals & requirements
- ❑ Network security analysis
- ❑ Security measures
- ❑ Bibliography



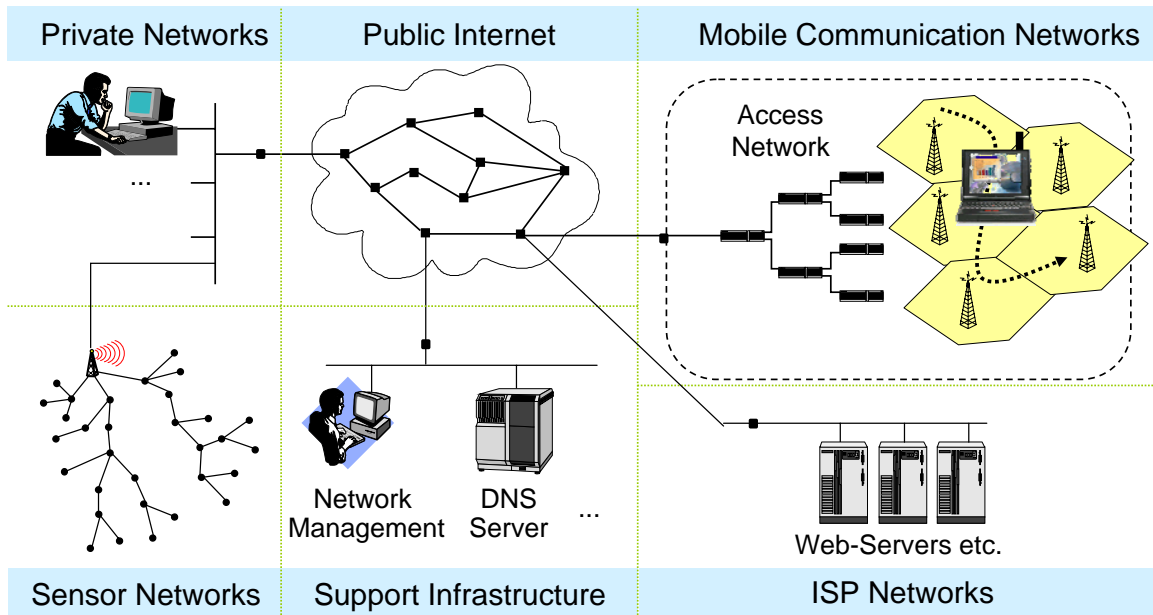
Motivation: A Changing World

- ❑ Mobile communication networks and ubiquitous availability of the global Internet have already changed dramatically the way we
 - communicate,
 - conduct business, and
 - organize our society
- ❑ With current research and developments in sensor networks and pervasive computing, we are even creating a new networked world
- ❑ However, the benefits associated with information and communication technology imply new vulnerabilities

➔ Increasing dependence of modern information society on availability and secure operation of communication services



A High Level Model for Internet-Based IT-Infrastructure





What is a Threat in a Communication Network?

- ❑ Abstract Definition:
 - A *threat* in a communication network is any possible event or sequence of actions that might lead to a violation of one or more *security goals*
 - The actual realization of a threat is called an *attack*
- ❑ Examples for threats:
 - A hacker breaking into a corporate computer
 - Disclosure of emails in transit
 - Someone changing financial accounting data
 - A hacker temporarily shutting down a website
 - Someone using services or ordering goods in the name of others
 - ...
- ❑ What are security goals?
 - Security goals can be defined:
 - depending on the application environment, or
 - in a more general, technical way



Security goals depending on the application environment (1)

- ❑ Banking:
 - Protect against fraudulent or accidental modification of transactions
 - Identify retail transaction customers
 - Protect PINs from disclosure
 - Ensure customers privacy
- ❑ Electronic trading:
 - Assure integrity of transactions
 - Protect corporate privacy
 - Provide legally binding electronic signatures on transactions
- ❑ Government:
 - Protect against disclosure of sensitive information
 - Provide electronic signatures on government documents



Security goals depending on the application environment (2)

- ❑ Public Telecommunication Providers:
 - Restrict access to administrative functions to authorized personnel
 - Protect against service interruptions
 - Protect subscribers privacy
- ❑ Corporate / Private Networks:
 - Protect corporate / individual privacy
 - Ensure message authenticity
- ❑ All Networks:
 - Prevent outside penetrations (who wants hackers?)

- ❑ Security goals are also called *security objectives*



Security Goals Technically Defined

- ❑ *Confidentiality* ("Vertraulichkeit"):
 - Data transmitted or stored should only be revealed to an intended audience
 - Confidentiality of entities is also referred to as *anonymity*
- ❑ *Data Integrity* ("Datenintegrität"):
 - It should be possible to detect any modification of data
- ❑ *Accountability* ("Zurechenbarkeit"):
 - It should be possible to identify the entity responsible for any communication event
 - Accountability directly supports non-repudiation ("Nicht-Abstreitbarkeit"), and also deterrence, intrusion prevention, security monitoring, and others
- ❑ *Availability* ("Verfügbarkeit"):
 - Services should be available and function correctly
- ❑ *Controlled Access* ("kontrollierter Zugang"):
 - Only authorized entities should be able to access certain services or information



Threats Technically Defined (1)

- ❑ *Masquerade:*
 - An entity claims to be another entity (also called “Impersonation”)
- ❑ *Eavesdropping:*
 - An entity reads information it is not intended to read
- ❑ *Loss or Modification of (transmitted) Information:*
 - Data is being altered or destroyed
- ❑ *Denial of Communication Acts (Repudiation):*
 - An entity falsely denies its participation in a communication act
- ❑ *Forgery of Information:*
 - An entity creates new information in the name of another entity
- ❑ *Sabotage/Denial of Service*
 - Any action that aims to reduce the availability and / or correct functioning of services or systems
- ❑ *Authorization Violation:*
 - An entity uses a service or resources it is not intended to use



Threats and Technical Security Goals

- ❑ The realization of a threat (attack) will try to break one or more security goals:

Technical Security Goals	General Threats						
	Masquerade	Eavesdropping	Authorization Violation	Loss or Modification of (transmitted) information	Denial of Communication acts	Forgery of Information	Sabotage (e.g. by overload)
Confidentiality	x	x	x				
Data Integrity	x		x	x		x	
Accountability	x		x	x	x	x	
Availability	x		x				x
Controlled Access	x		x	x		x	

- ❑ These threats are often combined in order to perform an attack!



Network Security Analysis

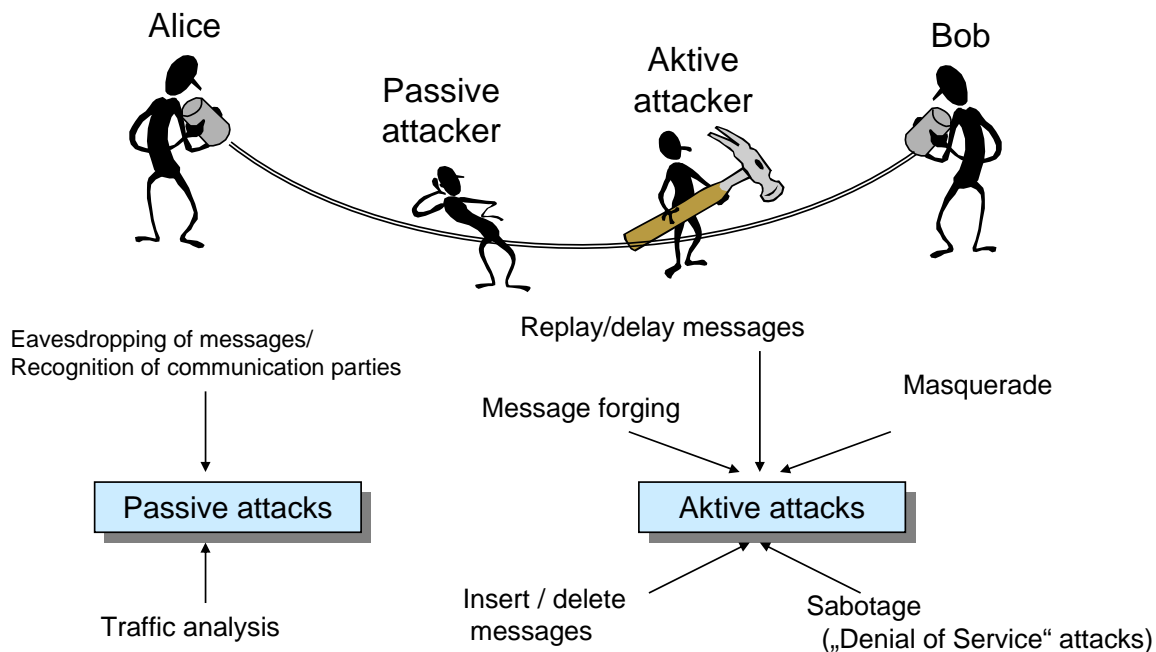
- ❑ In order to take appropriate countermeasures against threats, these have to be evaluated appropriately for a given network configuration.
- ❑ Therefore, a detailed *network security analysis* is needed that:
 - evaluates the potential risk of the threats to the entities using a network, and
 - estimates the expenditure (resources, time, etc.) needed to perform known attacks.

→ Attention: *It is generally impossible to assess unknown attacks!*

- ❑ A detailed security analysis of a given network configuration / a specific protocol architecture:
 - may be required to convince financially controlling entities in an enterprise to grant funding for security enhancements
 - can be structured according to the more fine grained *attacks on the message level*.



Attacks on Communication Networks



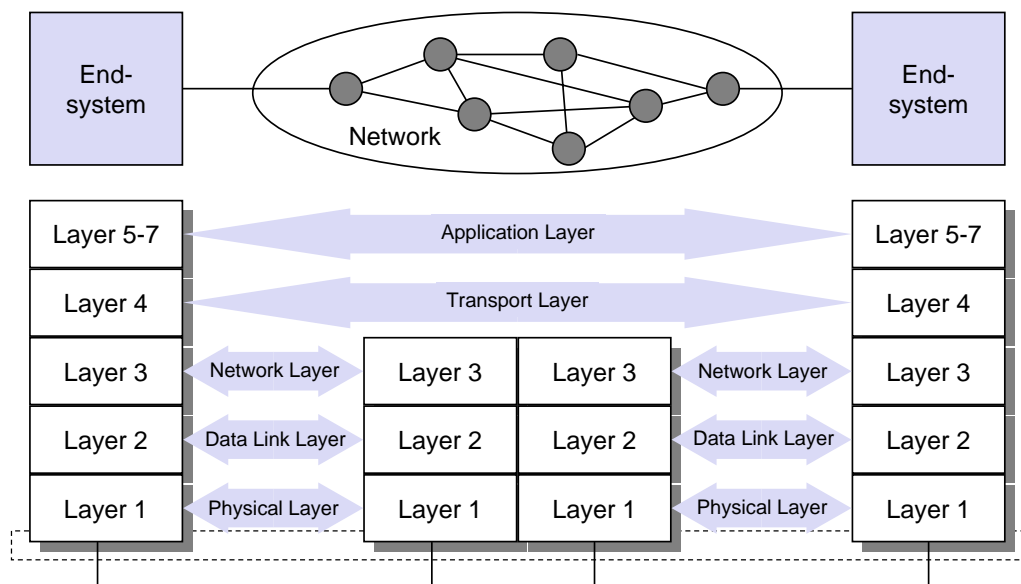


Attacking Communications on the Message Level

- Passive attacks:
 - Eavesdropping of messages
- Active attacks:
 - Delay of messages
 - Replay of messages
 - Deletion of messages
 - Modification of messages
 - Insertion of messages
- A security analysis of a protocol architecture has to analyse these attacks according to the architecture's layers

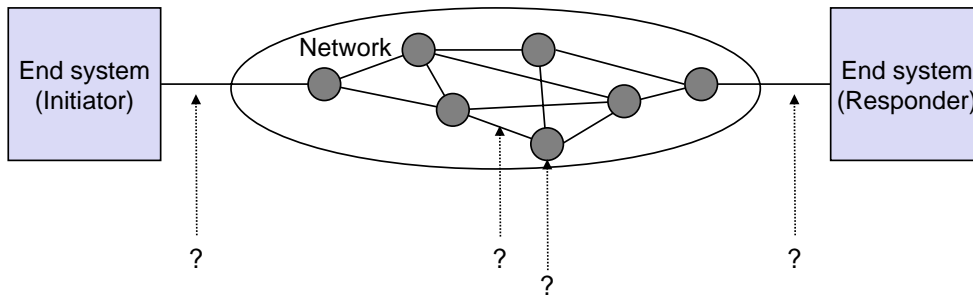


Communication in Layered Protocol Architectures





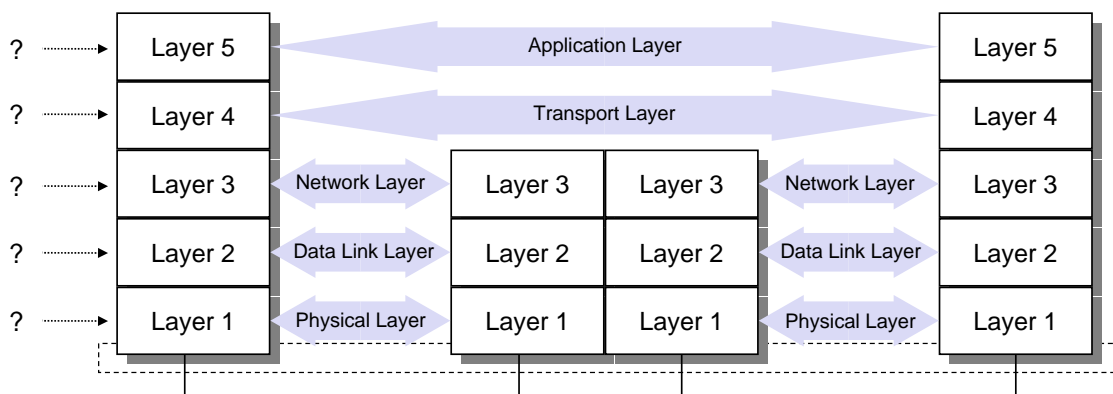
Security Analysis of Layered Protocol Architectures (1)



Dimension 1: At which interface does the attack take place?



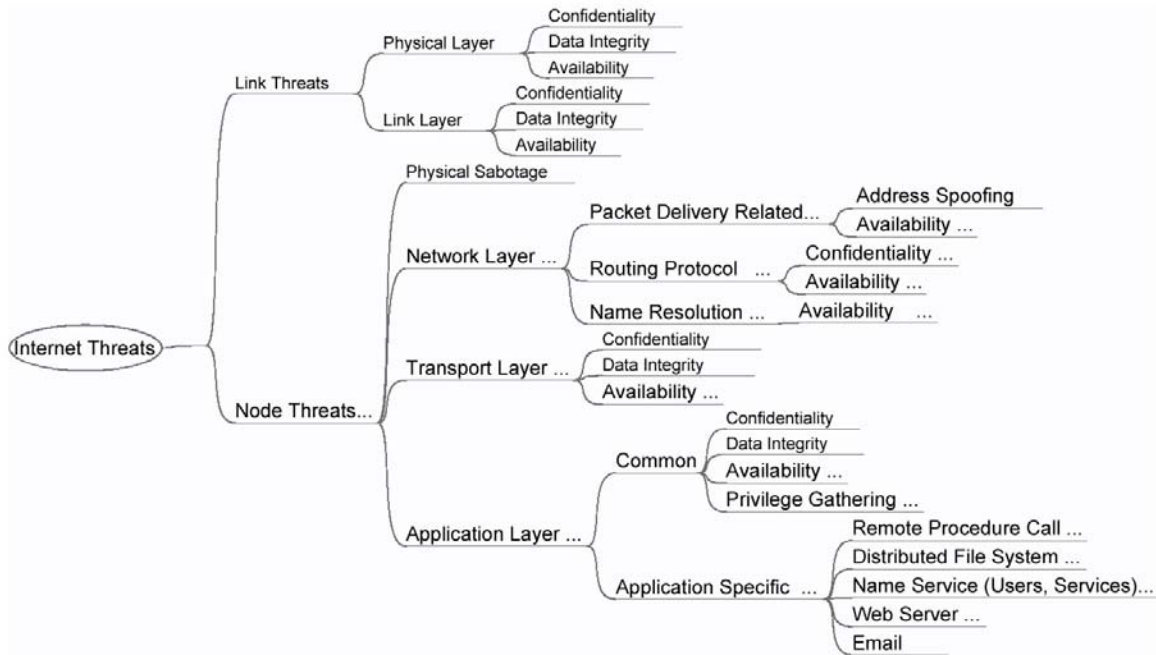
Security Analysis of Layered Protocol Architectures (2)



Dimension 2: In which layer does the attack take place?



A High Level Threat Tree for Internet-Based IT-Infrastructure



Measures against Information Security Threats (1)

- ❑ *Physical Security:*
 - Locks or other physical access control
 - Tamper-proofing of sensitive equipment
(c.f. Tamper resistance and tamper-evident systems)
- ❑ *Personnel Security:*
 - Identification of position sensitivity
 - Employee screening processes
 - Security training and awareness
- ❑ *Administrative Security:*
 - Controlling import of foreign software
 - Procedures for investigating security breaches
 - Reviewing audit trails
 - Reviewing accountability controls
- ❑ *Emanations Security:*
 - Radio Frequency and other electromagnetic emanations controls



Measures against Information Security Threats (2)

- ❑ *Media Security:*
 - Safeguarding storage of information
 - Controlling marking, reproduction and destruction of sensitive information
 - Ensuring that media containing sensitive information are destroyed securely
 - Scanning media for viruses
- ❑ *Lifecycle Controls:*
 - Trusted system design, implementation, evaluation and endorsement
 - Programming standards and controls
 - Documentation controls
- ❑ *Computer Security:*
 - Protection of information while stored / processed in a computer system
 - Protection of the computing devices itself
- ❑ *Communications Security: (the main subject of this course)*
 - Protection of information during transport from one system to another
 - Protection of the communication infrastructure itself



Communications Security: Some Terminology

- ❑ **Security Service:**
 - An abstract service that seeks to ensure a *security goal*
 - A security service can be realised with the help of cryptographic algorithms and protocols as well as with conventional means:
 - One can keep an electronic document on a floppy disk confidential by storing it on the disk in an encrypted format as well as locking away the disk in a safe
 - Usually a combination of cryptographic and other means is most effective
 - Fundamental security services:
 - Confidentiality
 - Entity authentication
 - Message authentication
 - Access control
 - Intrusion detection



Security Services – Overview

- ❑ *Confidentiality*
 - The most popular security service, ensuring the secrecy of protected data
- ❑ *Entity Authentication*
 - The most fundamental security service which ensures that an entity has in fact the identity it claims to have
- ❑ *Message Authentication*
 - This service ensures that the source of a message can be verified (*data origin authentication*) and that data can not be modified without detection (*data integrity*)
- ❑ *Access Control*
 - Controls that each identity accesses only those services and information it is entitled to
- ❑ *Intrusion detection*



Cryptographic Algorithm and Cryptographic Protocol

- ❑ *Cryptographic Algorithm:*
 - A mathematical transformation of input data (e.g. data, key) to output data
 - Cryptographic algorithms are used in cryptographic protocols
- ❑ *Cryptographic Protocol:*
 - A series of steps and message exchanges between multiple entities in order to achieve a specific security objective
- ❑ *Security Supporting Mechanism:*
 - Security relevant functionality which is part of a cryptographic protocol or of a security procedure



Security Supporting Mechanisms

- General mechanisms:
 - *Key management*: All aspects of the lifecycle of cryptographic keys
 - *Random number generation*: Generation of cryptographically secure random numbers
 - *Event detection / security audit trail*: Detection and recording of events that might be used in order to detect attacks or conditions that might be exploited by attacks
 - *Intrusion detection*: Analysis of recorded security data in order to detect successful intrusions or attacks
 - *Notarization*: Registration of data by a trusted third party that can confirm certain properties (content, creator, creation time) of the data later on
- Communication specific mechanisms:
 - *Traffic Padding*: Creation of bogus traffic in order to prevent traffic flow analysis
 - *Routing Control*: Influencing the routing of messages in a network



Course Overview (to be updated during the course)

- | | |
|---|---|
| 2. Basics of cryptography | 9. The IPSec architecture for the Internet Protocol |
| 3. Symmetric cryptography | 10. Security protocols of the transport layer |
| 4. Asymmetric cryptography | 11. Internet Firewalls |
| 5. Modification check values | 12. Security of wireless local area networks |
| 6. Cryptographic protocols | 13. Security of GSM and UMTS networks |
| 7. Integrating security services into communication architectures | 14. Intrusion Detection |
| 8. Security protocols of the data link layer | |



- Main books:
 - [Bless05] R. Bless, S. Mink, E.-O. Blaß, M. Conrad, H.-J. Hof, K. Kutzner, M. Schöller: "Sichere Netzwerkkommunikation", Springer, 2005, ISBN: 3-540-21845-9
 - [Ferg03] Niels Ferguson, B. Schneier: "Practical Cryptography", Wiley, 1st edition, March 2003
 - [Sch03] G. Schäfer. Netzsicherheit – Algorithmische Grundlagen und Protokolle. Soft cover, 422 pages, dpunkt.verlag, 2003.
 - [Sch96] B. Schneier. Applied Cryptography - Second Edition: Protocols, Algorithms and Source Code in C. John Wiley & Sons, 1996.

- Additional references will be provided for each chapter depending on the topic