Economic Aspects Of Information Security

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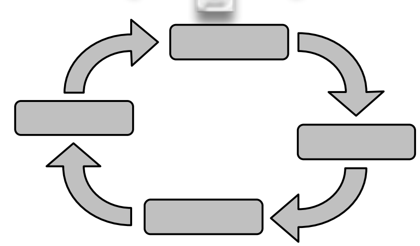
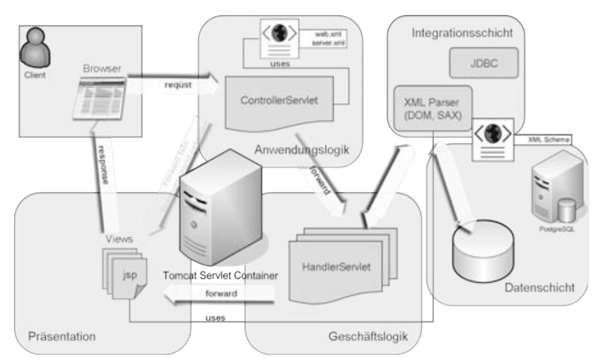
Agenda

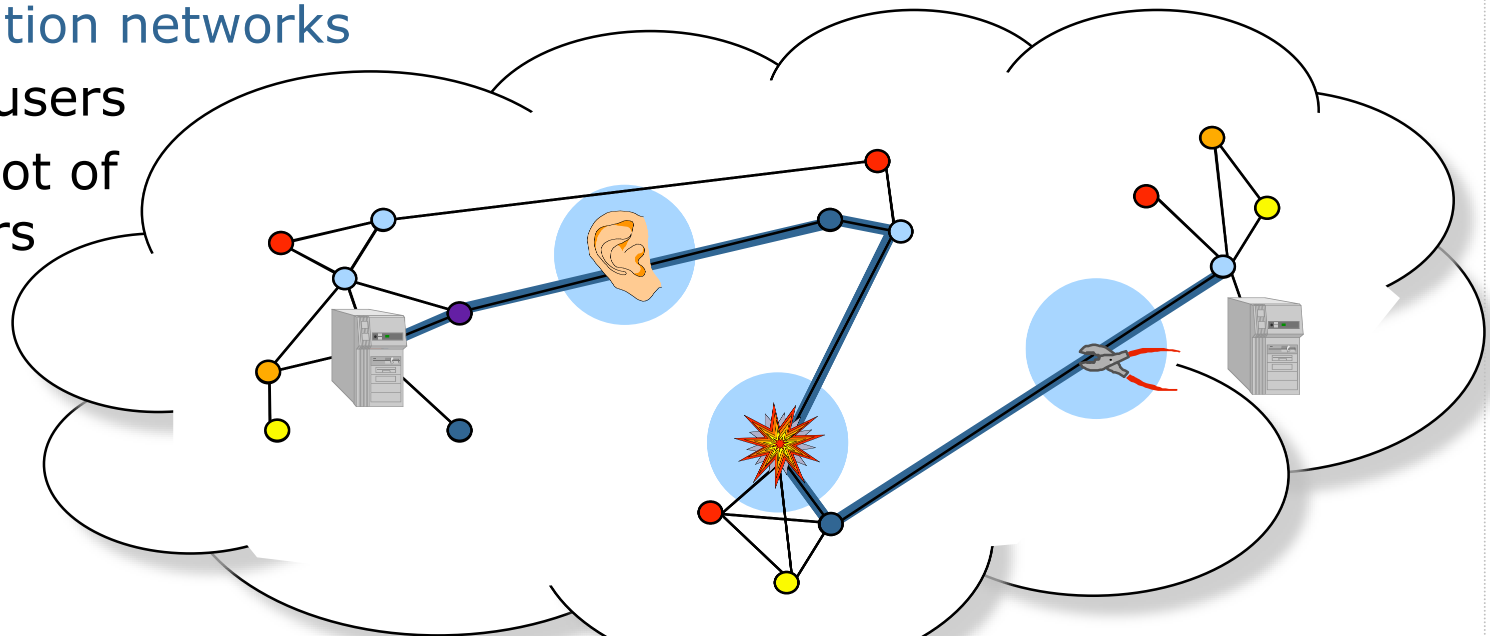
- What is information security?
- Technical building blocks
- Risk management cycle
- Return on Security Investment
- Architecture for Collecting quantitative historical data





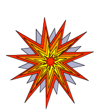
What is information security?

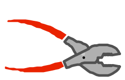
- Communication networks
  - a lot of users
  - quite a lot of operators



Threats

 Unauthorized acquisition of information

 Unauthorized modification of information

 Unauthorized impairment of functionality

Protection goals

Confidentiality

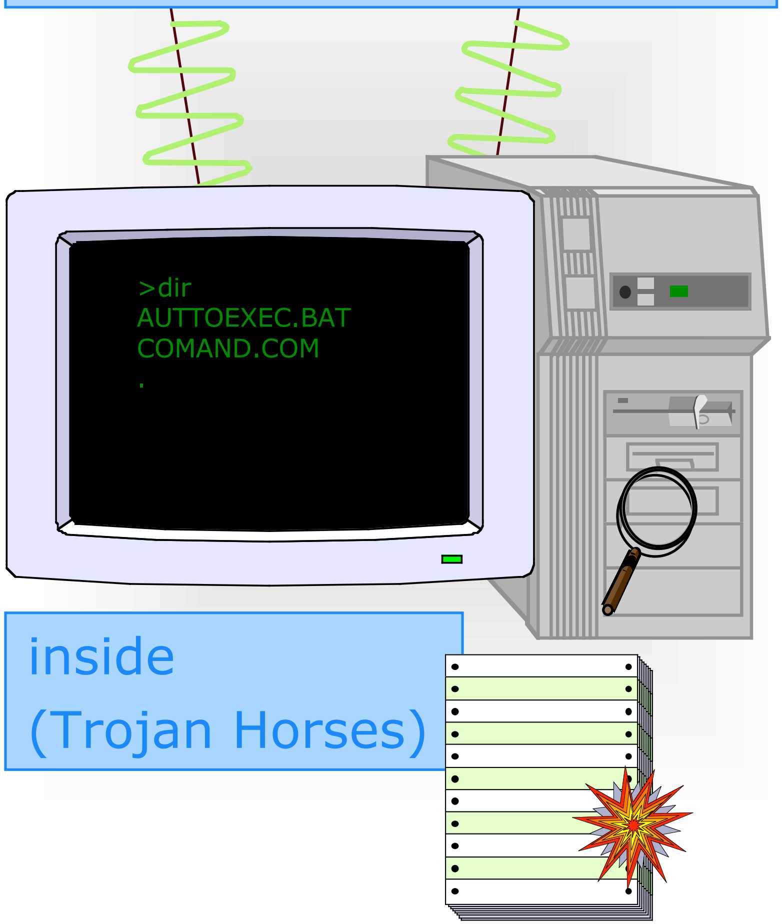
Integrity

Availability

Potential attacks

Nodes (computers)

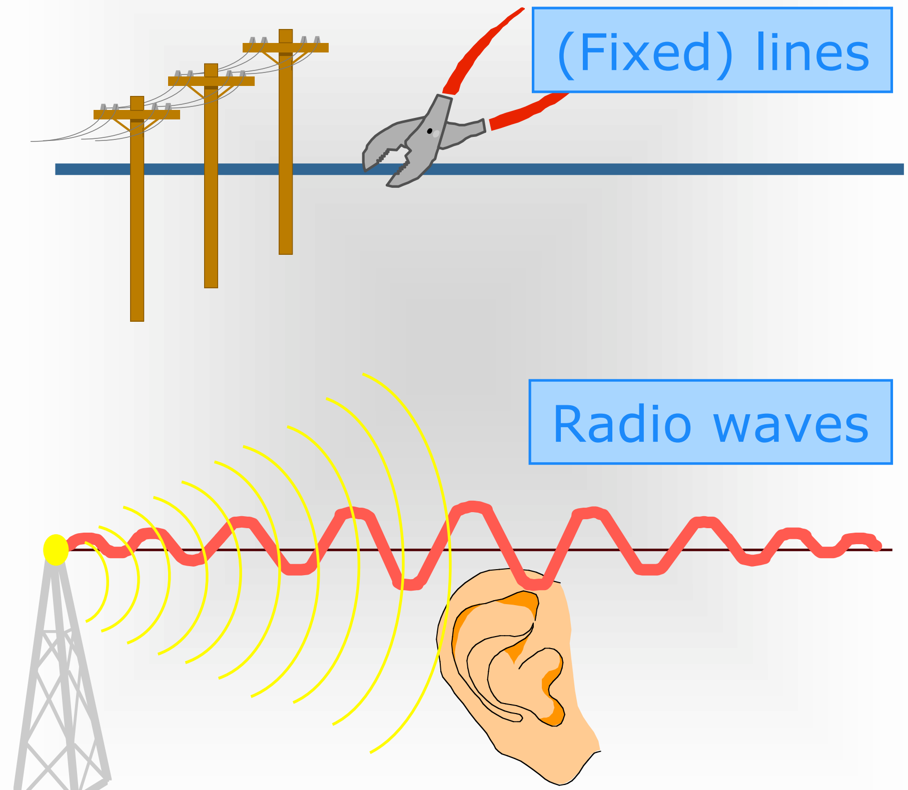
outside
(electromagnetic radiation)



inside
(Trojan Horses)

communication channels

(Fixed) lines



Radio waves

outside only

Typical attack sequence

1. Gaining information
   - IP addresses, passwords, entry points
2. Attack (mostly via the Internet)
   - exploits, weak protocols, misuse of data/passwords etc.
3. Extension of access privileges
   - particularly installation of a back door
4. remove traces
   - delete or manipulate log files

Protection goals

Confidentiality

Integrity

Availability

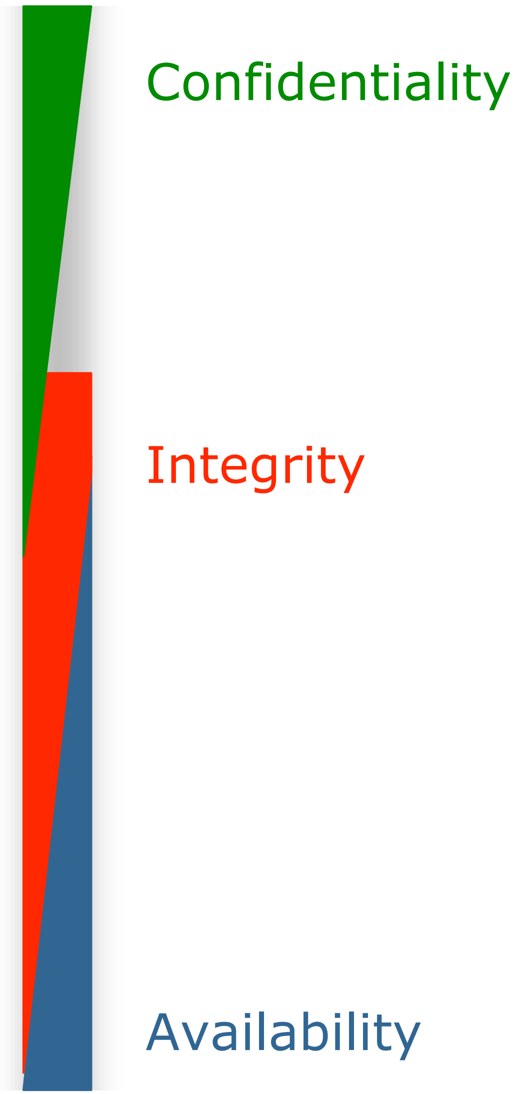
Protection Goals

Subject of communication WHAT?	Circumstances of communication WHEN?, WHERE?, WHO?
Confidentiality Hiding Contents	Anonymity Unobservability Sender Location Recipient
Integrity Contents	Accountability Legal Enforcement Sender Billing Recipient
Availability	

Types of attacks

- Passive attacks
  - eavesdropping
  - traffic analysis

- Active attacks
  - masquerading
    - man-in-the-middle attack
  - modification of data
  - injection of data
    - replay
    - flooding, spamming
  - denial of service



Technical building blocks

Confidentiality
Hiding

Integrity
Accountability
Legal Enforcement

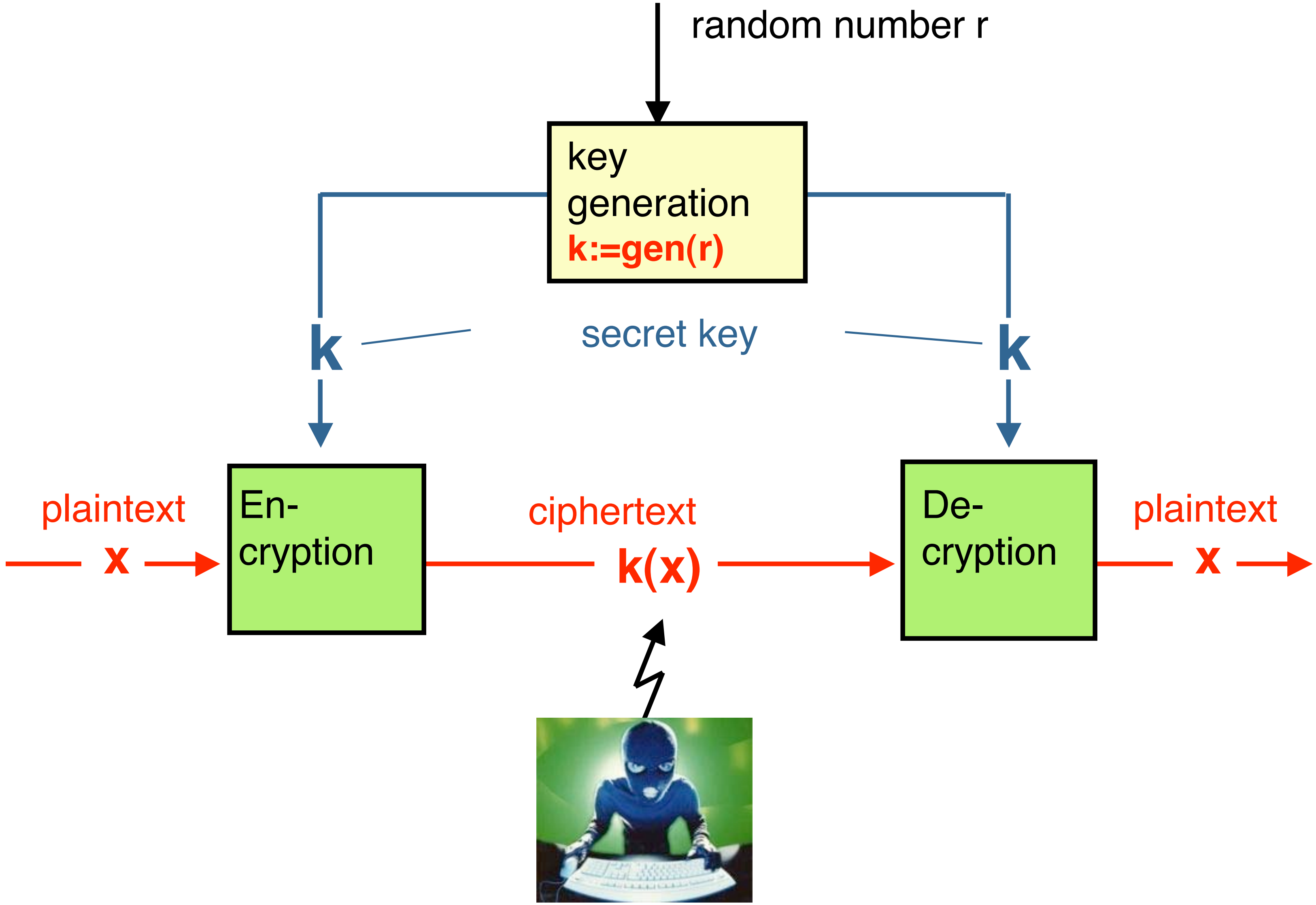
Anonymity
Unobservability

Availability

- Symmetric Encryption:
  - one key, two copies
- Asymmetric Encryption: two keys
  - public key: everybody knows it
  - private key: known by recipient
- Steganography:
  - hiding the existence of content

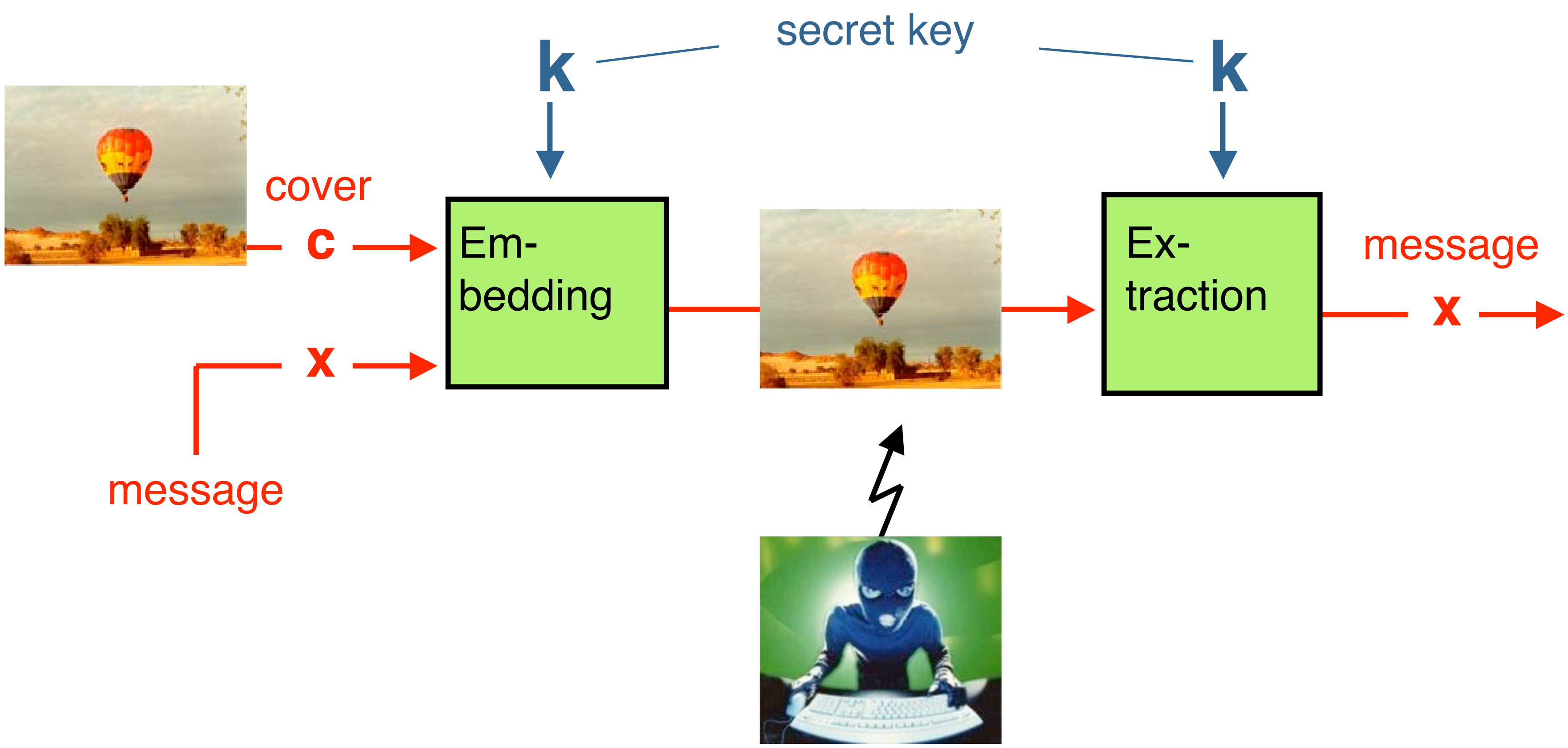
Symmetric Encryption

- one key, two copies



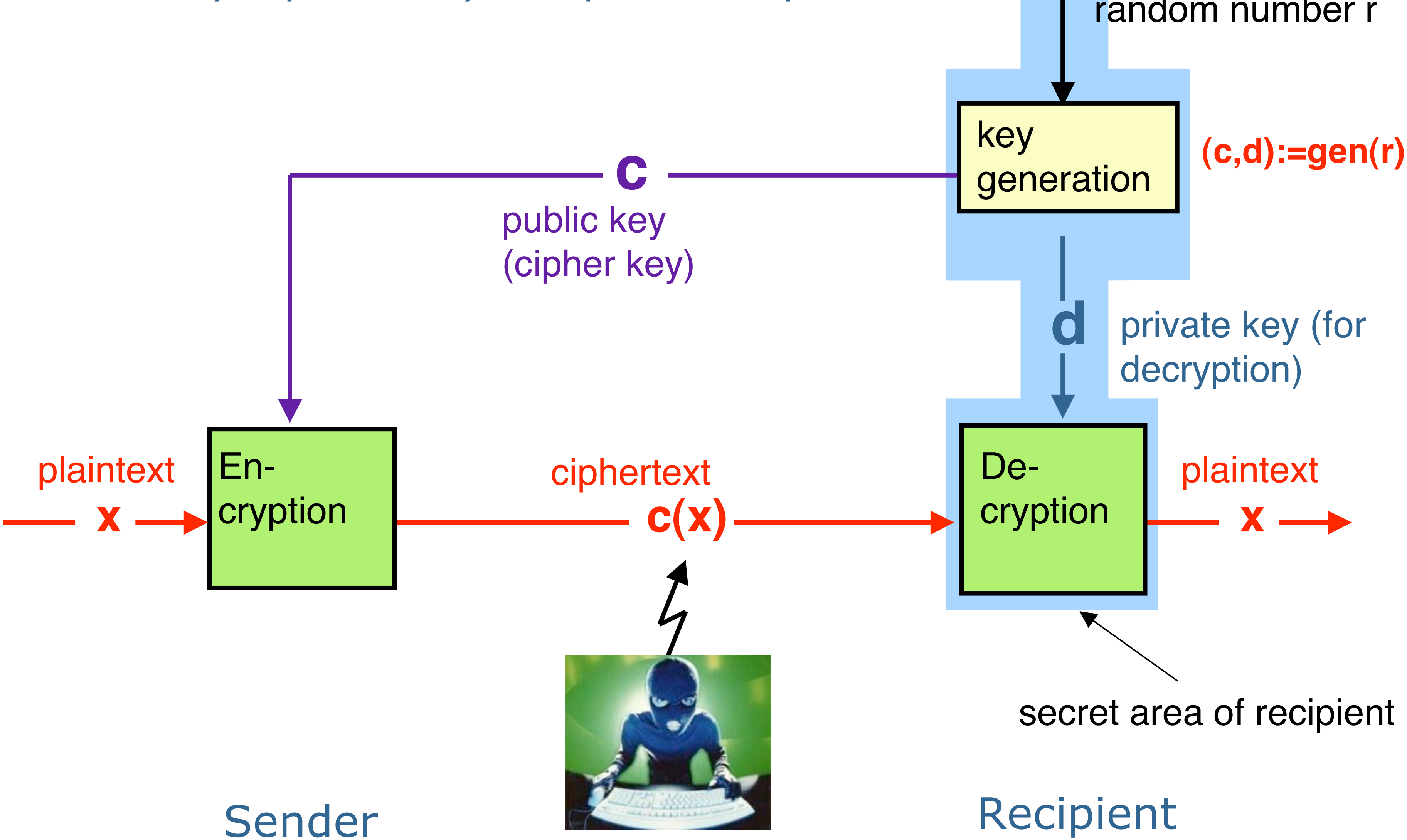
Steganography

- hiding the existence of content



Asymmetric Encryption

- two keys: public key and private key



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- Asymmetric Encryption: two keys
  - public key: everybody knows it
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  - hiding the existence of content

Encryption and Steganography
- Fast, secure and cheap!

PGP.com
GnuPG.org

Technical building blocks

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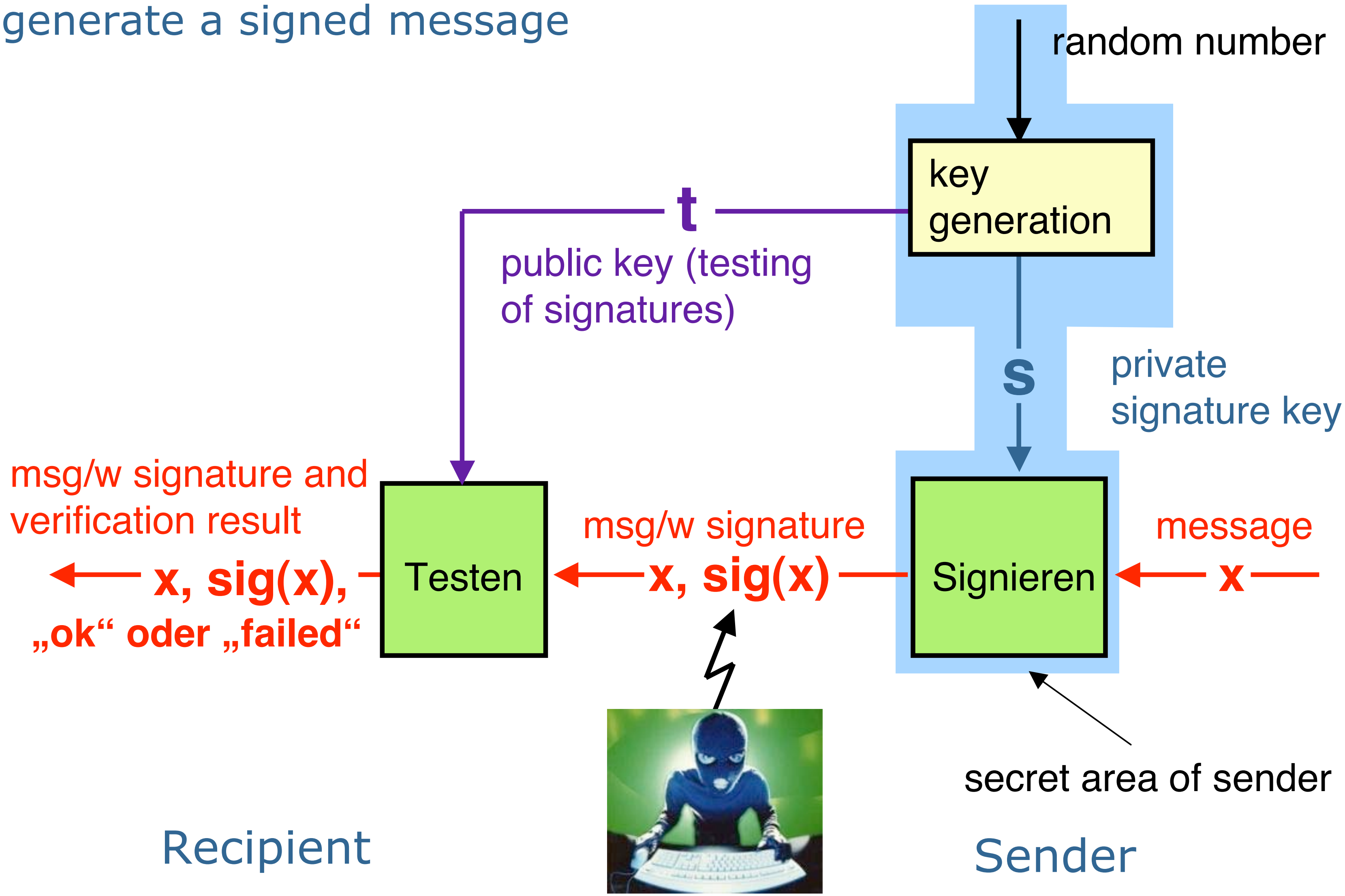
Availability

- Message Authentication Codes
  - based on symmetric encryption
  - protects from modification by external attacks
  - fast, secure and cheap
- Digital signatures
  - based on asymmetric encryption
  - two keys
    - public key: everybody knows it
    - private key: known by recipient
  - private key used to sign a document
  - public key used to verify
  - allows legal accountability and enforcement (similar to contract signing in the real world)

Digital Signature

- only the sender can generate a signed message



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Availability

- Digital signatures
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  - two keys
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  - private key used to sign a document
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Availability

- Digital signatures in the real world are
  - Fast, secure, but:
    - Expensive!

More exactly:
Tech. cheap
Orga. expensive

- Digital signatures
  - based on asymmetric encryption
  - two keys
    - public key: everybody knows it
    - private key: known by recipient
  - private key used to sign a document
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  - allows legal accountability and enforcement (similar to contract signing in the real world)

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Availability

- Public key infrastructure (expensive)
  - authenticity of public keys has to be ensured by technical (cheap) and organizational (expensive) means:
    - digital key certificates (e.g. X.509)
- Certification authority has to
  - check physical identification documents
  - process is handled by paper (legal issues)
  - for every user, year after year
- Costs (for handling paperwork and the physical process)
  - 10 - 150 EUR per certificate p.a.
- 80 Mill. Germans: > 1 billion EUR
  - Who should pay for the security?

☐ The signer ☒ The recipient

Technical building blocks

Confidentiality
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Availability

- Protection of privacy
  - Anonymity: Protection of the identity of a user while using a service (e.g. counseling services)
  - Unobservability: Protection of the communication relations of users
- Internationally agreed privacy principles (e.g. EU Privacy Directive of 1995)
  - no covert collections of personal information
  - informed consent to purpose prior to collection
  - retention and use only according to agreed purpose

Technical building blocks

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Availability

- Reality:
  - organizations ignore privacy
  - international
- Privacy activists
  - develop anonymization tools
    - http://tor.eff.org
    - http://www.anon-online.org
- To respect the privacy laws is
  1. a matter of legal compliance,
  2. a marketing issue (acceptance of privacy friendly systems) and
  3. cheap!

No storage of personal data, no effort for privacy protection.

Technical building blocks

Confidentiality
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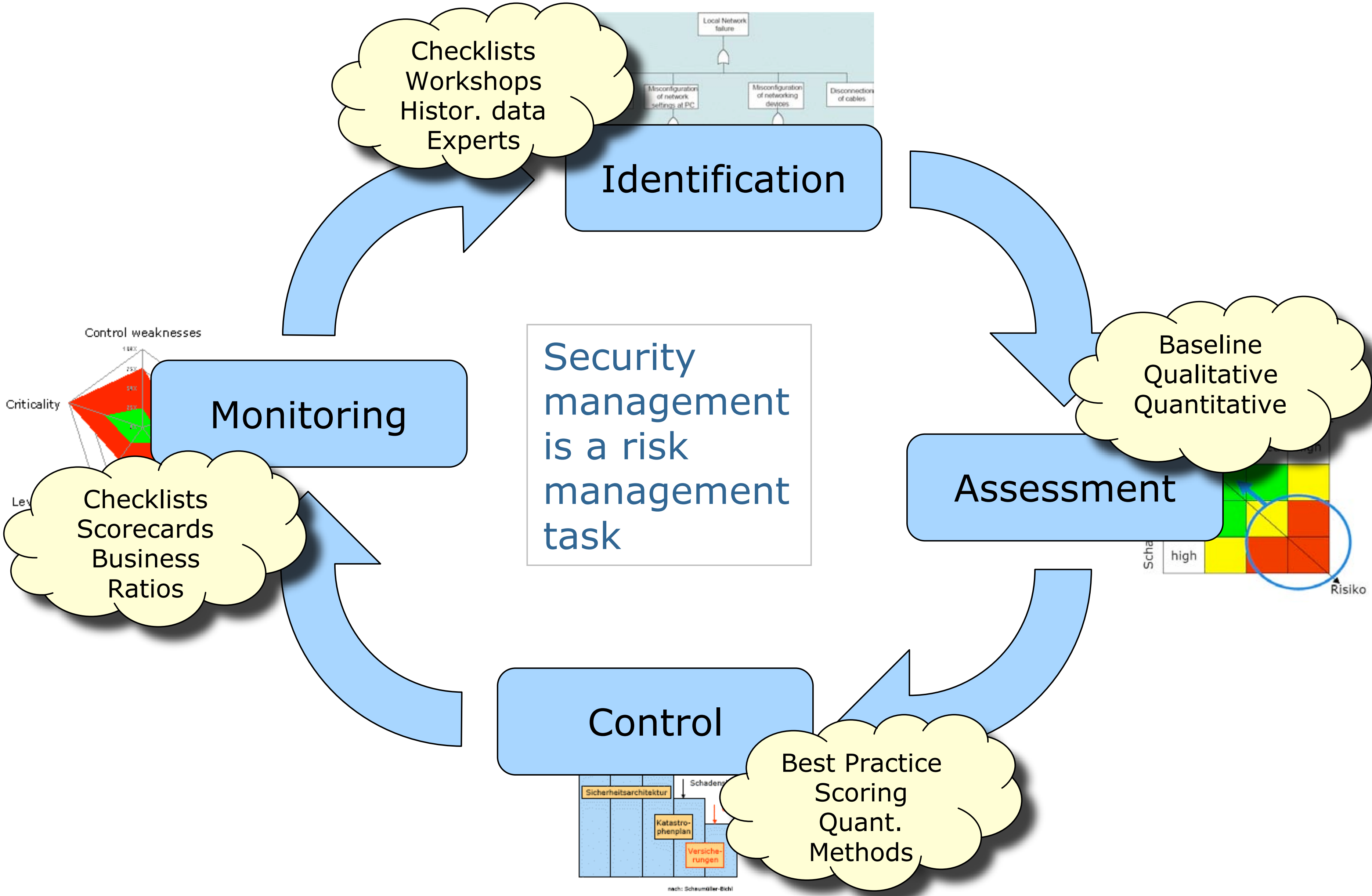
Availability

- Availability:
  - ensures that data and services are accessible to the user within a certain period of time
- Two Mechanisms:
  - Redundancy: duplication of components or repetition of operations to provide alternative functional channels in case of failure
  - Diversity: functional identical channels with a variety of designs provide reliable functionality in case of (software) failure

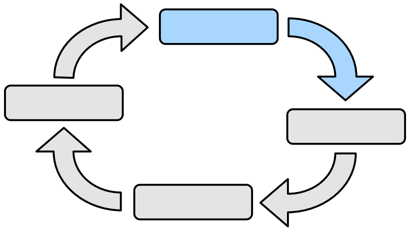
- Redundancy and diversity:
  - Expensive

Risk management

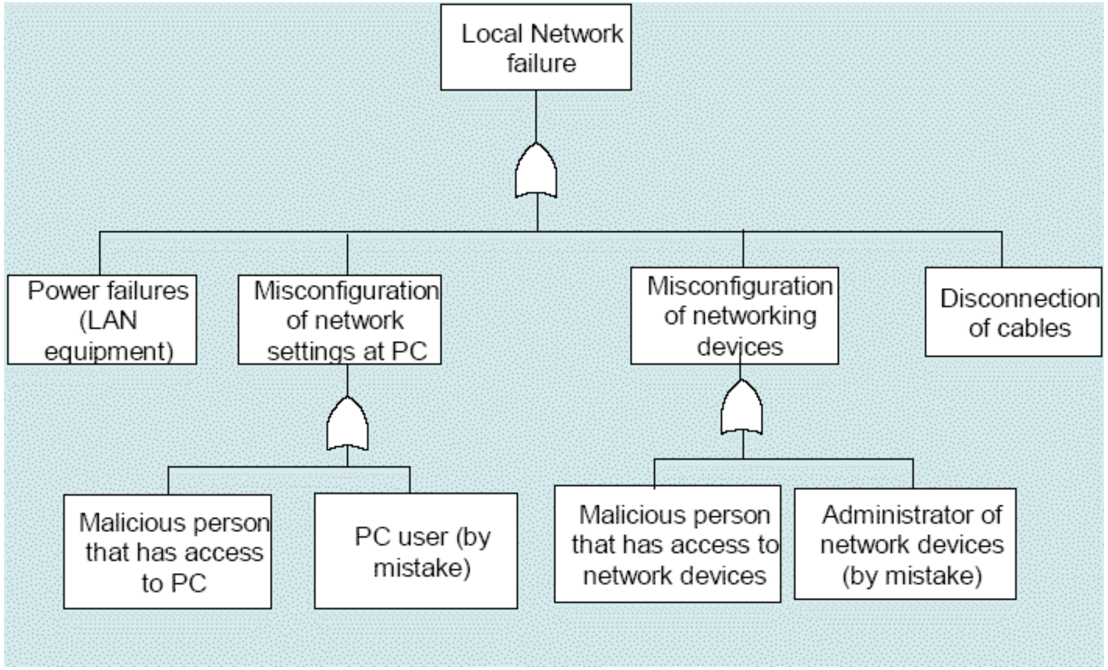
Risk management cycle



Identification of threats

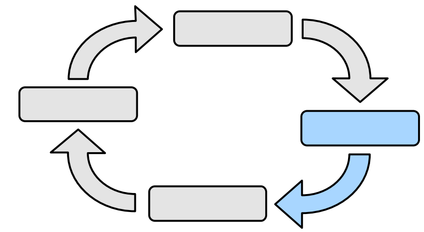


- Question
  - »What are the threats?«
- Methods & Tools
  - checklists
  - workshops
  - attack trees
  - fault trees
- Challenge
  - cover all threats

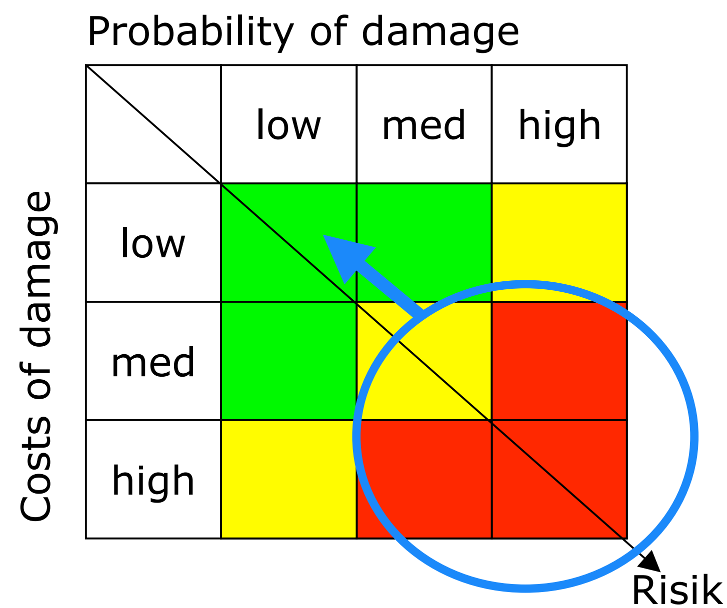


Assessment of threats

- Question
  - »What are the probabilities and consequences of threats?«
  - Risk = probability * consequence

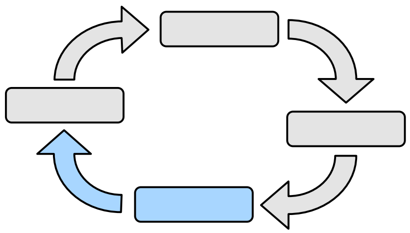


- Methods & Tools
  - qualitative assessment
  - quantitative assessment
  - game theory
- Challenges
  - dependency from assets
  - strategic attackers
  - correlations between threats
  - source of (quantitative) input

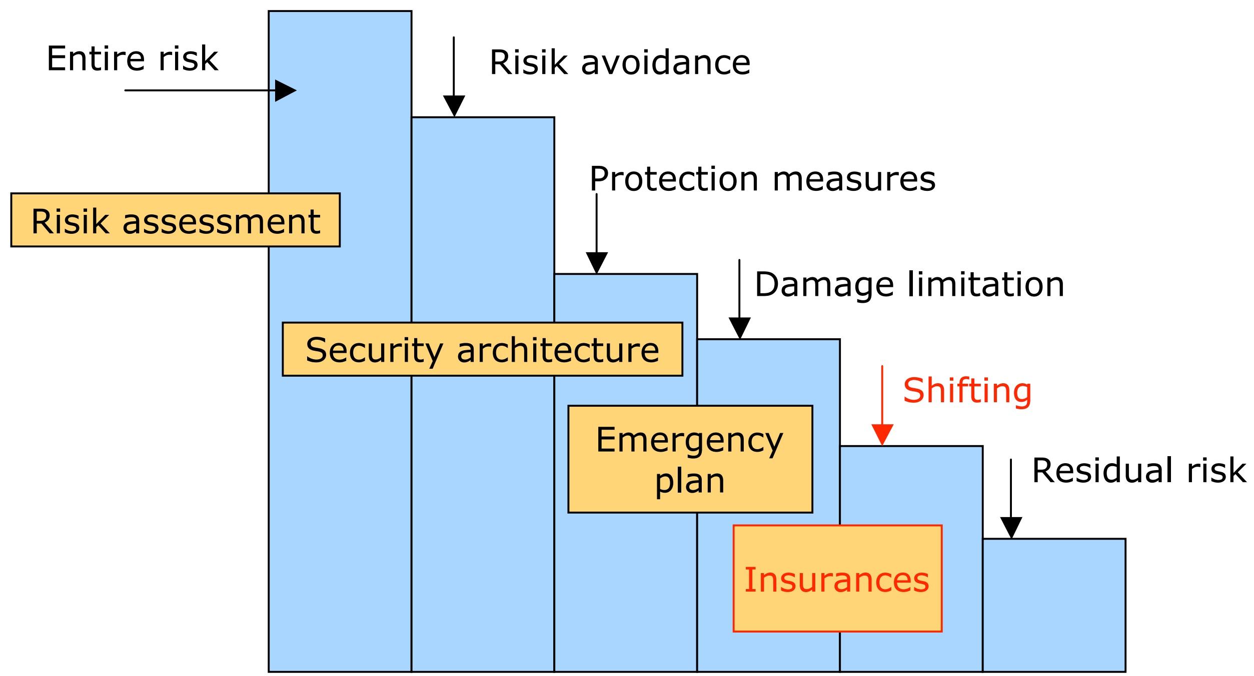


Control of threats

- Question
  - »How to handle risks?«



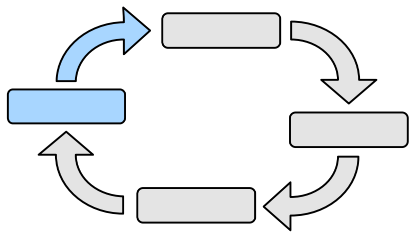
- Methods
  - best practice approaches
  - baseline protection



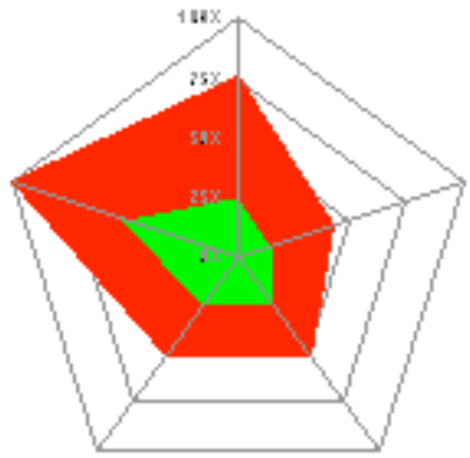
according to: Schaumüller-Bichl

Monitoring of risks and measures

- Questions
  - »Were the measures effective and efficient?«
    »What is the current protection level?«

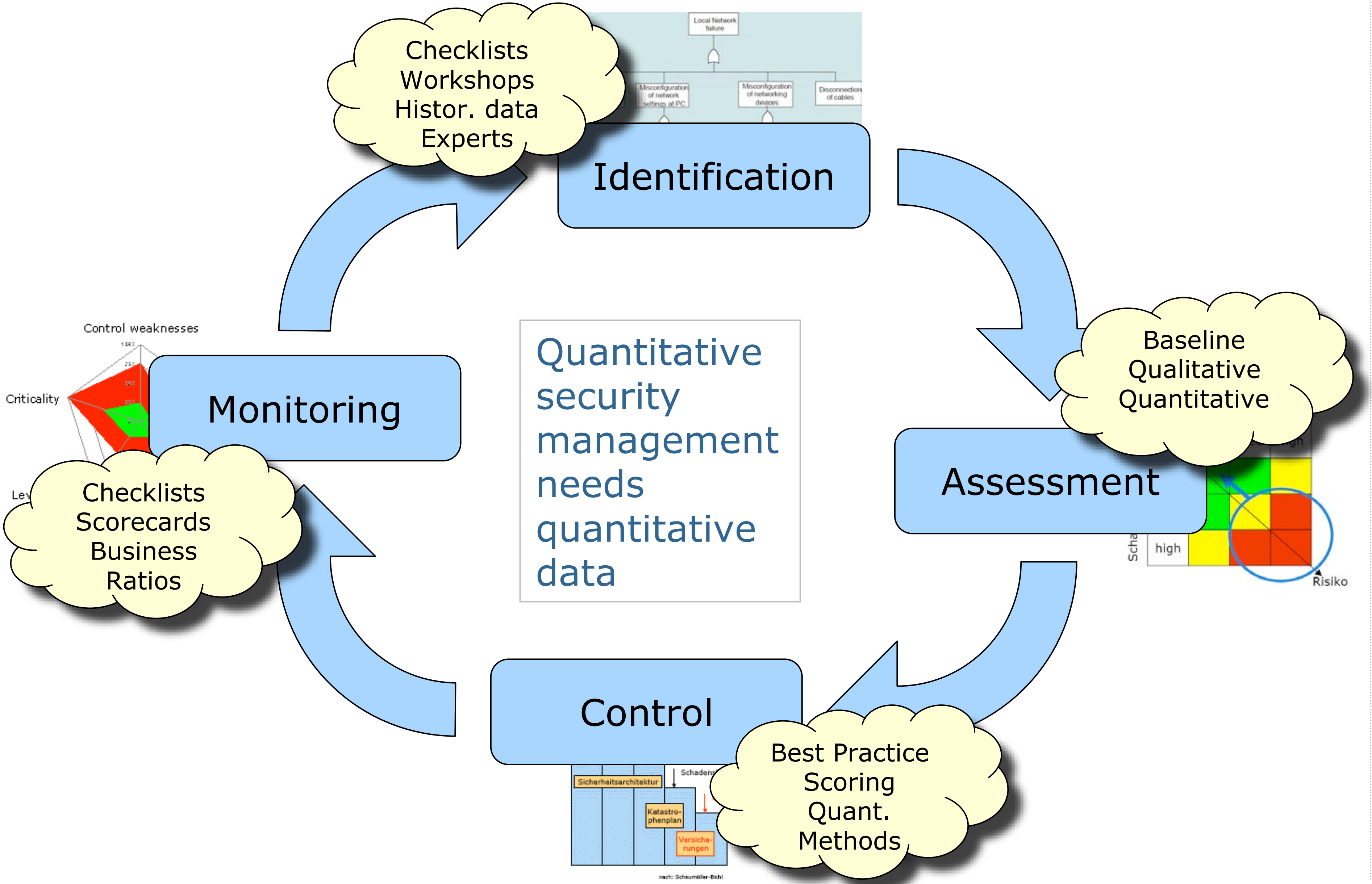


- Method
  - scorecard approaches



according to: Loomans, 2002

Risk management cycle



Return on Security Investment (ROSI)

- based on the calculation of an annual loss expectancy for a certain undesirable event (threat): (FIBS 1979)

$$ALE = SLE \cdot ARO$$

ALE: annual loss expectancy

SLE: single loss expectancy

ARO: annual rate of occurrence

- aggregation of ALEs of several events: (Soo Hoo 2000)

$$ALE = \sum_{i=1}^{n} S(O_i)F_i$$

O_i: harmful outcome i

$S(O_i)$: Severity of O_i (in monetary units)

- Return on security investment: (Wei et. al 2001)

$$ROSI = ALE_0 - ALE_1 - \text{cost}$$

ALE_0-ALE_1: change of the ALE from year 0 to year 1

Cost: cost of the security measure

- if ROSI >0 then investment was advantageous

Return on Security Investment (ROSI)

- ROSI
  - Alternative calculation as a ratio: (Sonnenreich et. al. 2006)

$$ROSI = \frac{(\text{risk exposure} \cdot \%\ \text{risk mitigated}) - \text{cost}}{\text{cost}}$$

  - Another variation: (Pfleeger and Pfleeger 2003)

$$\text{risk leverage} = \frac{(\text{risk exp. before red.}) - (\text{risk exp. after red.})}{\text{cost of risk reduction}}$$

difference of risk exposure before and after reduction in relation to the costs of the measure

- Advantages
  - Different security measures can now be compared.
  - Security investments can now be compared with other investments (non-security).

Quantitative data is needed

- Risk assessment needs input:
  - probability of a security-related event and
  - level of damage (cost in case of …)
- Problem:
  - enterprises are not willing to reveal such information
  - loss of reputation/trust

Some information from the past

do something

cost

benefit = nothing happens

cost-benefit analysis

…

Detailed information (numbers) on past events

do the right

cost

benefit = nothing happens

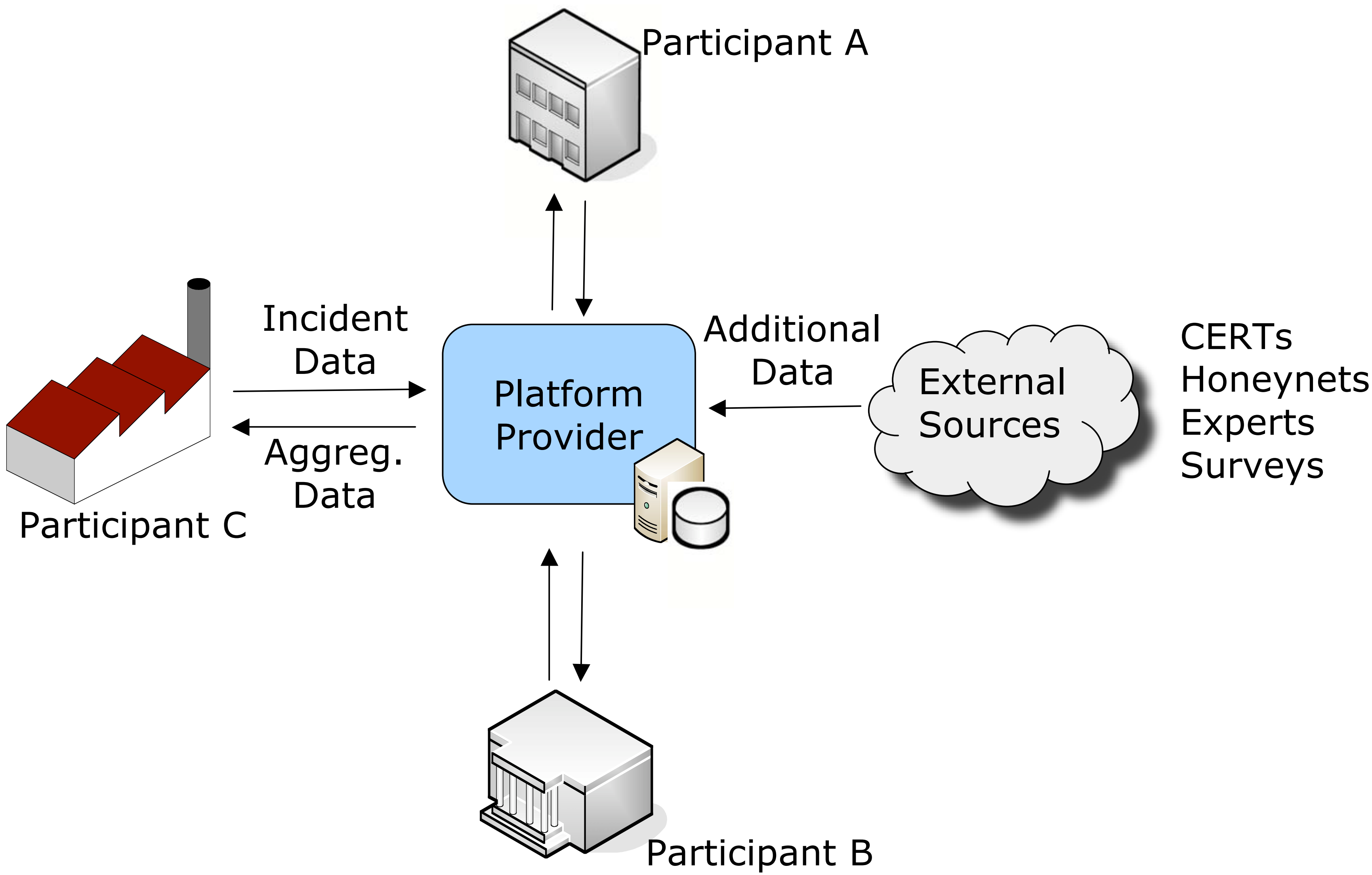
Potential Sources for Quantitative Data

Mechanism	Example	Evaluation
Expert Judgements	Interviews with internal or external experts CSI/FBI Survey	Used frequently, but not originally quantitative Subjective, incomplete
Simulations	Historical simulations Monte carlo simulations	Good, however reliable input data is needed
Market Mechanisms	Capital market analyses Exploit derivatives Bug challenges	Not applicable to all situations Not yet available
Historical Data	CERTS collect data on security events Internal incident reporting	Widely used in other areas (e.g. insurances) Past != Future Hardly available so far

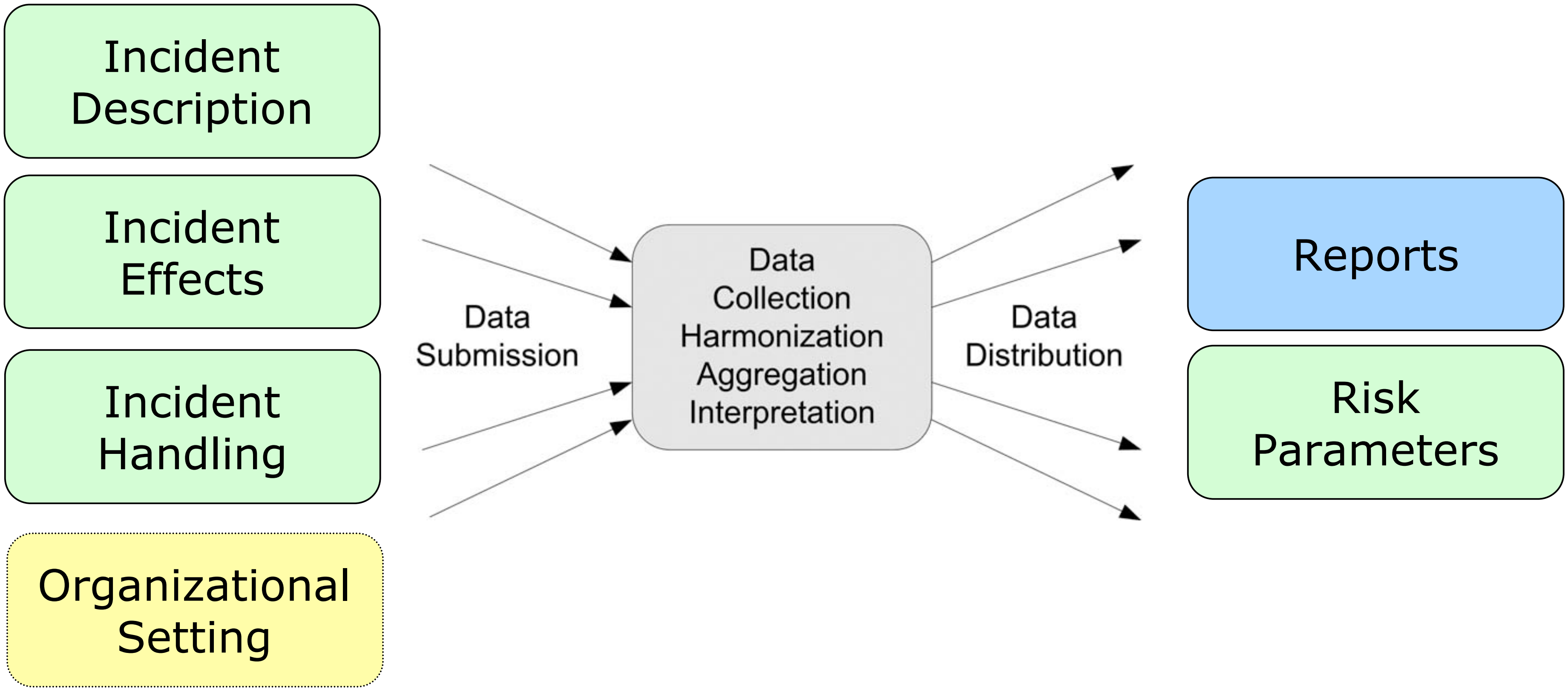
Idea: Collecting quantitative historical data

- Idea
  - Building a system for the collection of quantitative historical data on security incidents from different organizations
- Goal
  - A database that gives information about impact and frequency of security incidents
- Existing approaches have a different focus
- Microeconomic theory shows the utility of that concept
- Various possibilities to use that data
  - Risk assessment, investment decisions
  - Benchmarking between organizations
  - Examination of statistical distribution functions, correlations

Basic Architecture



Input and Output



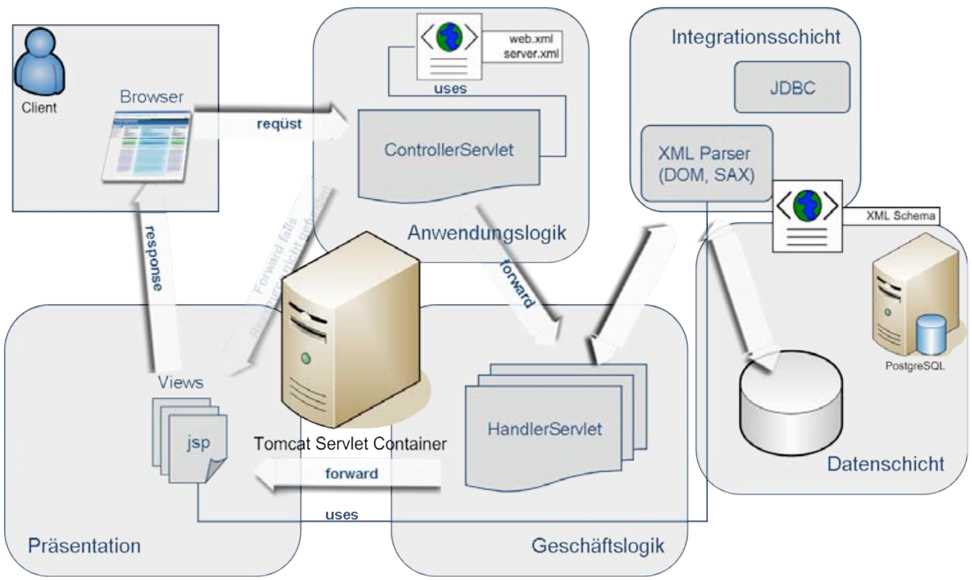
Fairness Requirements

- Two major problems known from economics
  - Free-riding
  - Truth-telling

- Mechanisms
  - Incentive system
  - Reputation system
  - Legal framework
  - Statistical checks for plausibility

Current State of Implementation

- Web-based multi-tier Application
  - Java Servlets, JavaServer Pages PostgreSQL
- Taxonomy realized as XML-schema
  - All incident reports in XML
- Already implemented
  - Data collection/transfer
  - Data storage
- Next steps
  - Data analysis mechanisms
  - Interface for ext. data
  - Deciding on mechanisms to provide fairness



Conclusions

- Security management becomes more challenging
  - Increasing dependence on information systems
  - Growing number of threats
  - Compliance requirements
- Security management is a risk management task
  - Measuring costs and benefits of security is challenging
  - Quantitative data is needed for modern security management
  - Historical data might be a solution for that problem

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