L12 – Software Security Assurance Process

Topics covered

- Security requirements
- Secure systems design
- Security testing and assurance

Security requirements

Security specification

- Security specification has something in common with safety requirements specification – in both cases, your concern is to avoid something bad happening.
- Four major differences
  - Safety problems are accidental – the software is not operating in a hostile environment. In security, you must assume that attackers have knowledge of system weaknesses
  - When safety failures occur, you can look for the root cause or weakness that led to the failure. When failure results from a deliberate attack, the attacker may conceal the cause of the failure.
  - Shutting down a system can avoid a safety-related failure. Causing a shut down may be the aim of an attack.
  - Safety-related events are not generated from an intelligent adversary. An attacker can probe defenses over time to discover weaknesses.

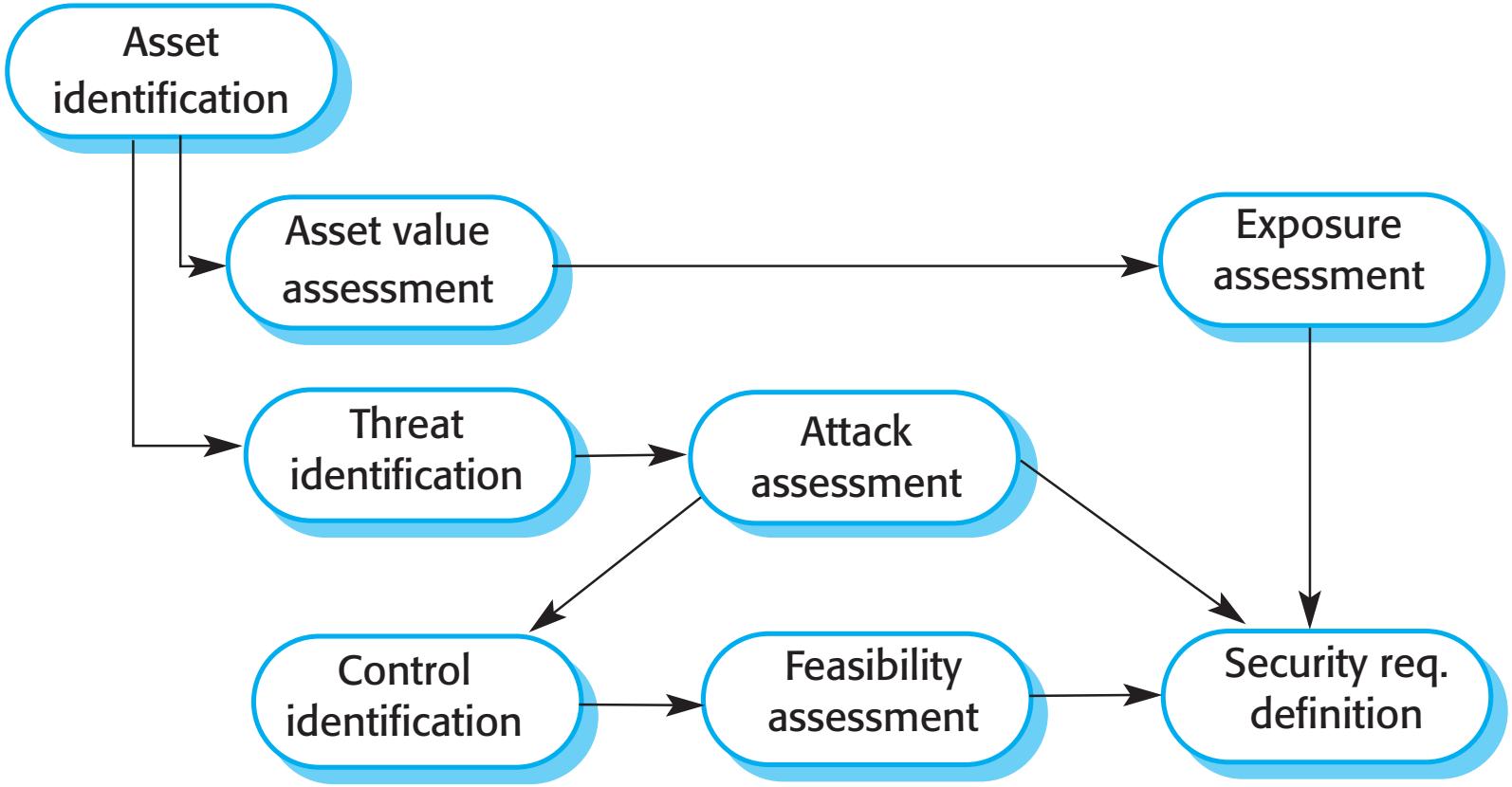
Types of security requirement

- Identification requirements.
- Authentication requirements.
- Authorization requirements.
- Integrity requirements.
- Intrusion detection requirements.
- Privacy requirements.
- Security auditing requirements.
- System maintenance security requirements.

Security requirement classification

- Risk avoidance requirements set out the risks that should be avoided by designing the system so that these risks simply cannot arise.
- Risk detection requirements define mechanisms that identify the risk if it arises and neutralise the risk before losses occur.
- Risk mitigation requirements set out how the system should be designed so that it can recover from and restore system assets after some loss has occurred.

The preliminary risk assessment process for security requirements



Security risk assessment

- Asset identification
  - Identify the key system assets (or services) that have to be protected.
- Asset value assessment
  - Estimate the value of the identified assets.
- Exposure assessment
  - Assess the potential losses associated with each asset.
- Threat identification
  - Identify the most probable threats to the system assets

Security risk assessment

- Attack assessment
  - Decompose threats into possible attacks on the system and the ways that these may occur.
- Control identification
  - Propose the controls that may be put in place to protect an asset.
- Feasibility assessment
  - Assess the technical feasibility and cost of the controls.
- Security requirements definition
  - Define system security requirements. These can be infrastructure or application system requirements.

Asset analysis in a preliminary risk assessment report for the Mentcare system

Asset	Value	Exposure
The information system	High. Required to support all clinical consultations. Potentially safety-critical.	High. Financial loss as clinics may have to be canceled. Costs of restoring system. Possible patient harm if treatment cannot be prescribed.
The patient database	High. Required to support all clinical consultations. Potentially safety-critical.	High. Financial loss as clinics may have to be canceled. Costs of restoring system. Possible patient harm if treatment cannot be prescribed.
An individual patient record	Normally low although may be high for specific high-profile patients.	Low direct losses but possible loss of reputation.

Threat and control analysis in a preliminary risk assessment report

Threat	Probability	Control	Feasibility
An unauthorized user gains access as system manager and makes system unavailable	Low	Only allow system management from specific locations that are physically secure.	Low cost of implementation but care must be taken with key distribution and to ensure that keys are available in the event of an emergency.
An unauthorized user gains access as system user and accesses confidential information	High	Require all users to authenticate themselves using a biometric mechanism. Log all changes to patient information to track system usage.	Technically feasible but high-cost solution. Possible user resistance. Simple and transparent to implement and also supports recovery.

Security requirements for the Mentcare system

- Patient information shall be downloaded at the start of a clinic session to a secure area on the system client that is used by clinical staff.
- All patient information on the system client shall be encrypted.
- Patient information shall be uploaded to the database after a clinic session has finished and deleted from the client computer.
- A log on a separate computer from the database server must be maintained of all changes made to the system database.

Secure systems design

Secure systems design

- Security should be designed into a system – it is very difficult to make an insecure system secure after it has been designed or implemented
- Architectural design
  - how do architectural design decisions affect the security of a system?
- Good practice
  - what is accepted good practice when designing secure systems?

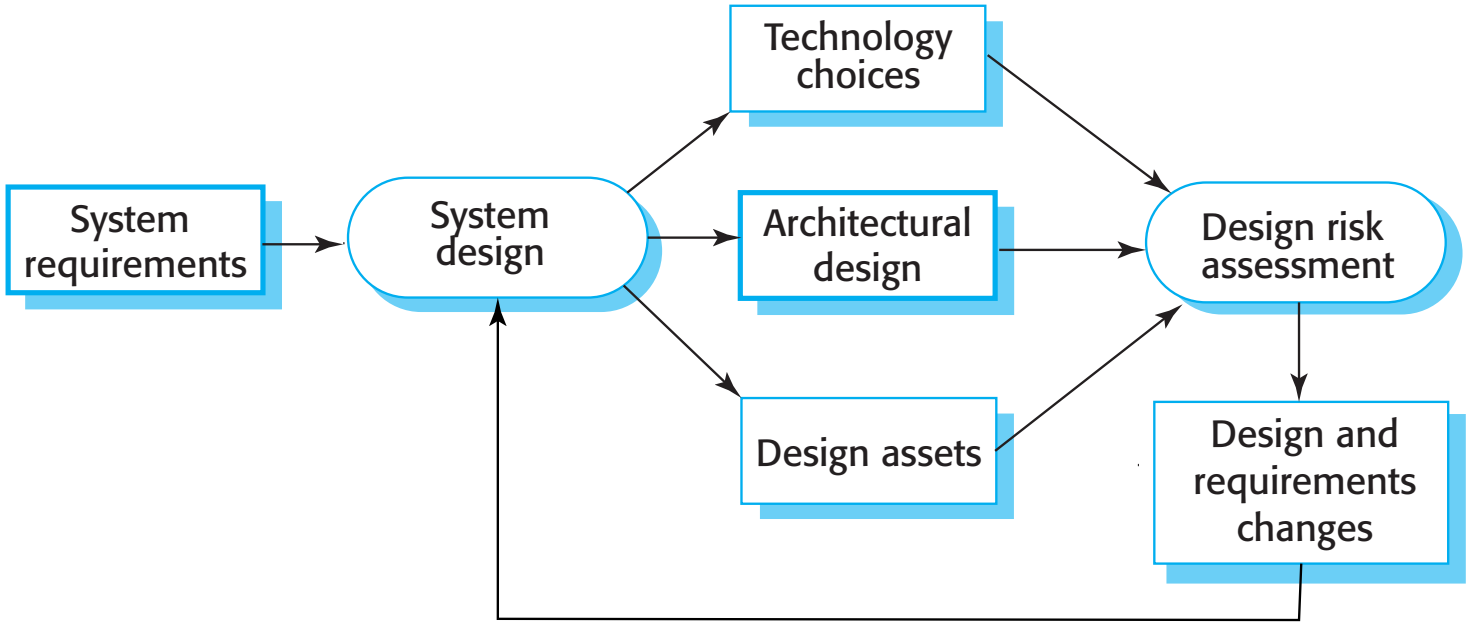
Design compromises

- Adding security features to a system to enhance its security affects other attributes of the system
- Performance
  - Additional security checks slow down a system so its response time or throughput may be affected
- Usability
  - Security measures may require users to remember information or require additional interactions to complete a transaction. This makes the system less usable and can frustrate system users.

Design risk assessment

- Risk assessment while the system is being developed.
- More information is available - system platform, middleware and the system architecture and data organization.
- Vulnerabilities that arise from design choices may therefore be identified.

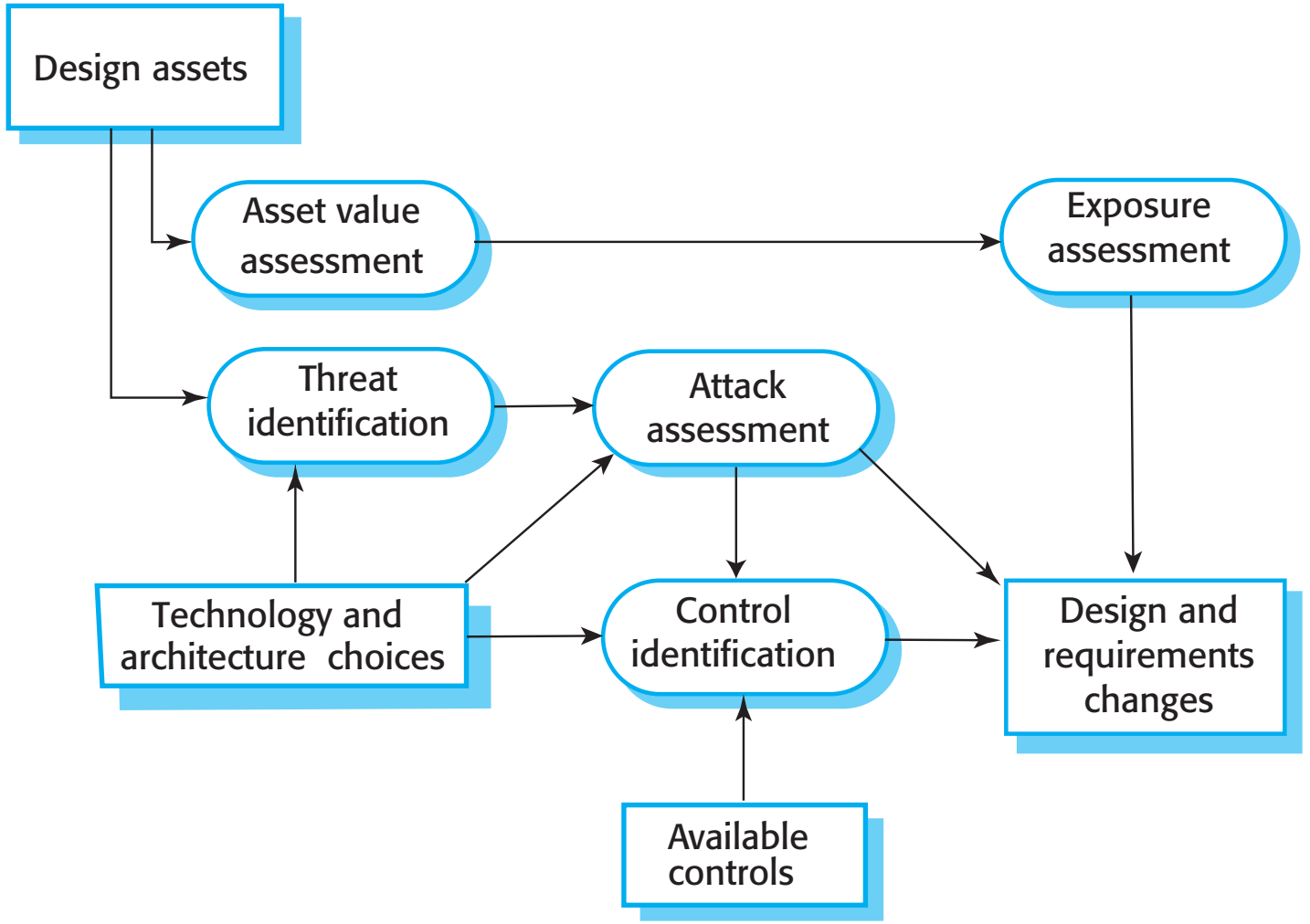
Design and risk assessment



Protection requirements

- Protection requirements may be generated when knowledge of information representation and system distribution
- Separating patient and treatment information limits the amount of information (personal patient data) that needs to be protected
- Maintaining copies of records on a local client protects against denial of service attacks on the server
  - But these may need to be encrypted

Design risk assessment



Design decisions from use of COTS

- System users authenticated using a name/password combination.
- The system architecture is client-server with clients accessing the system through a standard web browser.
- Information is presented as an editable web form.

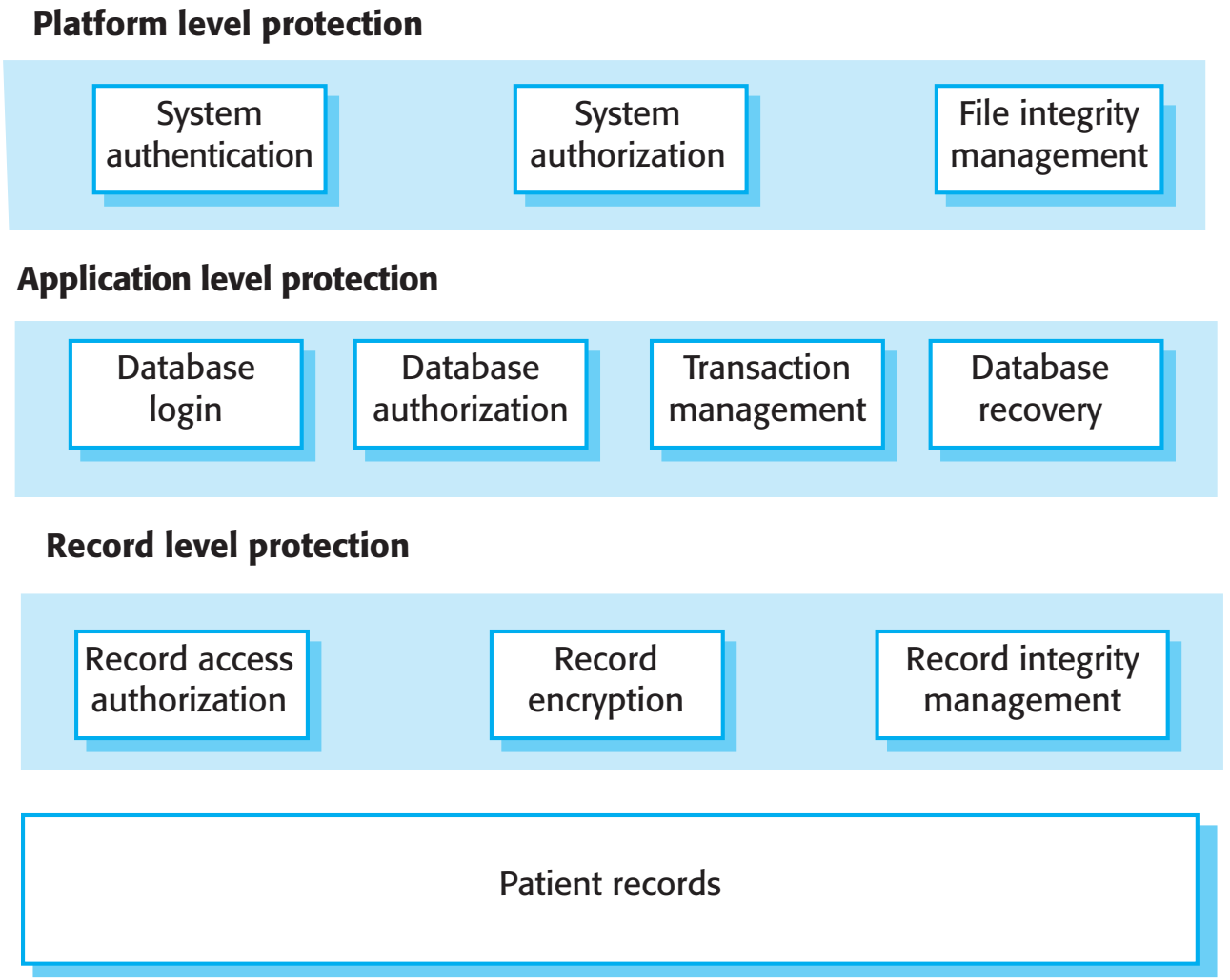
Architectural design

- Two fundamental issues have to be considered when designing an architecture for security.
  - Protection
    - How should the system be organised so that critical assets can be protected against external attack?
  - Distribution
    - How should system assets be distributed so that the effects of a successful attack are minimized?
- These are potentially conflicting
  - If assets are distributed, then they are more expensive to protect. If assets are protected, then usability and performance requirements may be compromised.

Protection

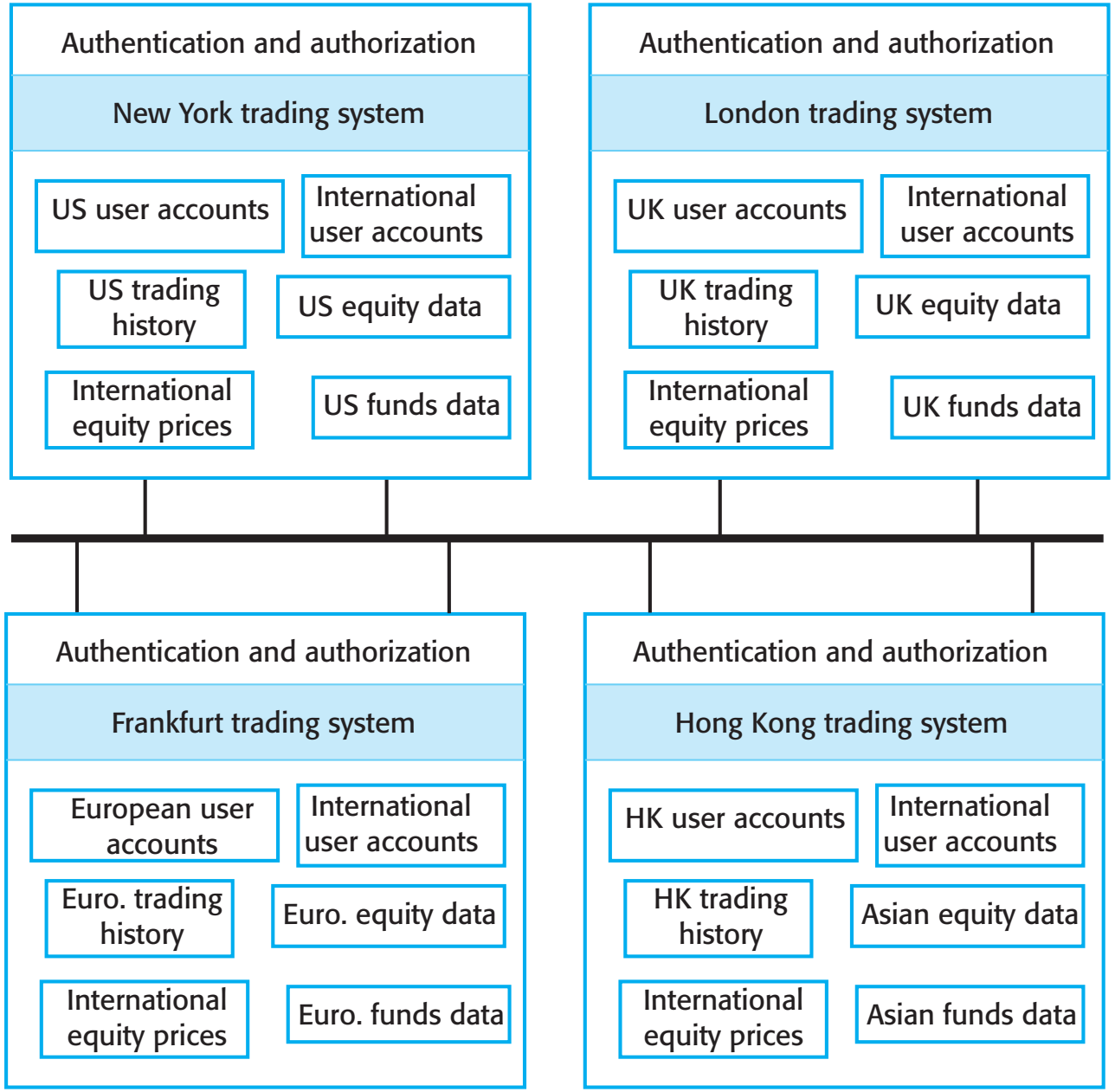
- Platform-level protection
  - Top-level controls on the platform on which a system runs.
- Application-level protection
  - Specific protection mechanisms built into the application itself e.g. additional password protection.
- Record-level protection
  - Protection that is invoked when access to specific information is requested
- These lead to a layered protection architecture

A layered protection architecture



Distribution

- Distributing assets means that attacks on one system do not necessarily lead to complete loss of system service
- Each platform has separate protection features and may be different from other platforms so that they do not share a common vulnerability
- Distribution is particularly important if the risk of denial of service attacks is high



Distributed assets in an equity trading

Design guidelines for security engineering

- Design guidelines encapsulate good practice in secure systems design
- Design guidelines serve two purposes:
  - They raise awareness of security issues in a software engineering team. Security is considered when design decisions are made.
  - They can be used as the basis of a review checklist that is applied during the system validation process.
- Design guidelines here are applicable during software specification and design

Design guidelines for secure systems engineering

Security guidelines	
Base security decisions on an explicit security policy	
Avoid a single point of failure	
Fail securely	
Balance security and usability	
Log user actions	
Use redundancy and diversity to reduce risk	
Specify the format of all system inputs	
Compartmentalize your assets	
Design for deployment	
Design for recoverability	

Design guidelines 1-3

- Base decisions on an explicit security policy
  - Define a security policy for the organization that sets out the fundamental security requirements that should apply to all organizational systems.
- Avoid a single point of failure
  - Ensure that a security failure can only result when there is more than one failure in security procedures. For example, have password and question-based authentication.
- Fail securely
  - When systems fail, for whatever reason, ensure that sensitive information cannot be accessed by unauthorized users even although normal security procedures are unavailable.

Design guidelines 4-6

- Balance security and usability
  - Try to avoid security procedures that make the system difficult to use. Sometimes you have to accept weaker security to make the system more usable.
- Log user actions
  - Maintain a log of user actions that can be analyzed to discover who did what. If users know about such a log, they are less likely to behave in an irresponsible way.
- Use redundancy and diversity to reduce risk
  - Keep multiple copies of data and use diverse infrastructure so that an infrastructure vulnerability cannot be the single point of failure.

Design guidelines 7-10

- Specify the format of all system inputs
  - If input formats are known then you can check that all inputs are within range so that unexpected inputs don’t cause problems.
- Compartmentalize your assets
  - Organize the system so that assets are in separate areas and users only have access to the information that they need rather than all system information.
- Design for deployment
  - Design the system to avoid deployment problems
- Design for recoverability
  - Design the system to simplify recoverability after a successful attack.

Secure systems programming

Aspects of secure systems programming

- Vulnerabilities are often language-specific.
  - Array bound checking is automatic in languages like Java so this is not a vulnerability that can be exploited in Java programs.
  - However, millions of programs are written in C and C++ as these allow for the development of more efficient software so simply avoiding the use of these languages is not a realistic option.
- Security vulnerabilities are closely related to program reliability.
  - Programs without array bound checking can crash so actions taken to improve program reliability can also improve system security.

Dependable programming guidelines

Dependable programming guidelines

1. **Limit the visibility of information in a program**
2. **Check all inputs for validity**
3. **Provide a handler for all exceptions**
4. **Minimize the use of error-prone constructs**
5. **Provide restart capabilities**
6. **Check array bounds**
7. **Include timeouts when calling external components**
8. **Name all constants that represent real-world values**

Security testing and assurance

Security testing

- Testing the extent to which the system can protect itself from external attacks.
- Problems with security testing
  - Security requirements are ‘shall not’ requirements i.e. they specify what should not happen. It is not usually possible to define security requirements as simple constraints that can be checked by the system.
  - The people attacking a system are intelligent and look for vulnerabilities. They can experiment to discover weaknesses and loopholes in the system.

Security validation

- Experience-based testing
  - The system is reviewed and analysed against the types of attack that are known to the validation team.
- Penetration testing
  - A team is established whose goal is to breach the security of the system by simulating attacks on the system.
- Tool-based analysis
  - Various security tools such as password checkers are used to analyse the system in operation.
- Formal verification
  - The system is verified against a formal security specification.

Examples of entries in a security checklist

Security checklist

1. Do all files that are created in the application have appropriate access permissions? The wrong access permissions may lead to these files being accessed by unauthorized users.

2. Does the system automatically terminate user sessions after a period of inactivity? Sessions that are left active may allow unauthorized access through an unattended computer.

3. If the system is written in a programming language without array bound checking, are there situations where buffer overflow may be exploited? Buffer overflow may allow attackers to send code strings to the system and then execute them.

4. If passwords are set, does the system check that passwords are ‘strong’? Strong passwords consist of mixed letters, numbers, and punctuation, and are not normal dictionary entries. They are more difficult to break than simple passwords.

5. Are inputs from the system’s environment always checked against an input specification? Incorrect processing of badly formed inputs is a common cause of security vulnerabilities.