ECS 235B Module 25
Design Assurance Techniques

Design Assurance

- Process of establishing that design of system sufficient to enforce security requirements
  - Specify requirements
  - Specify system design
  - Examine how well design meets requirements

Design Techniques

- Modularity
  - Makes system design easier to analyze
  - RVM: functions not related to security distinct from modules supporting security functionality
- Layering
  - Makes system easier to understand
  - Supports information hiding

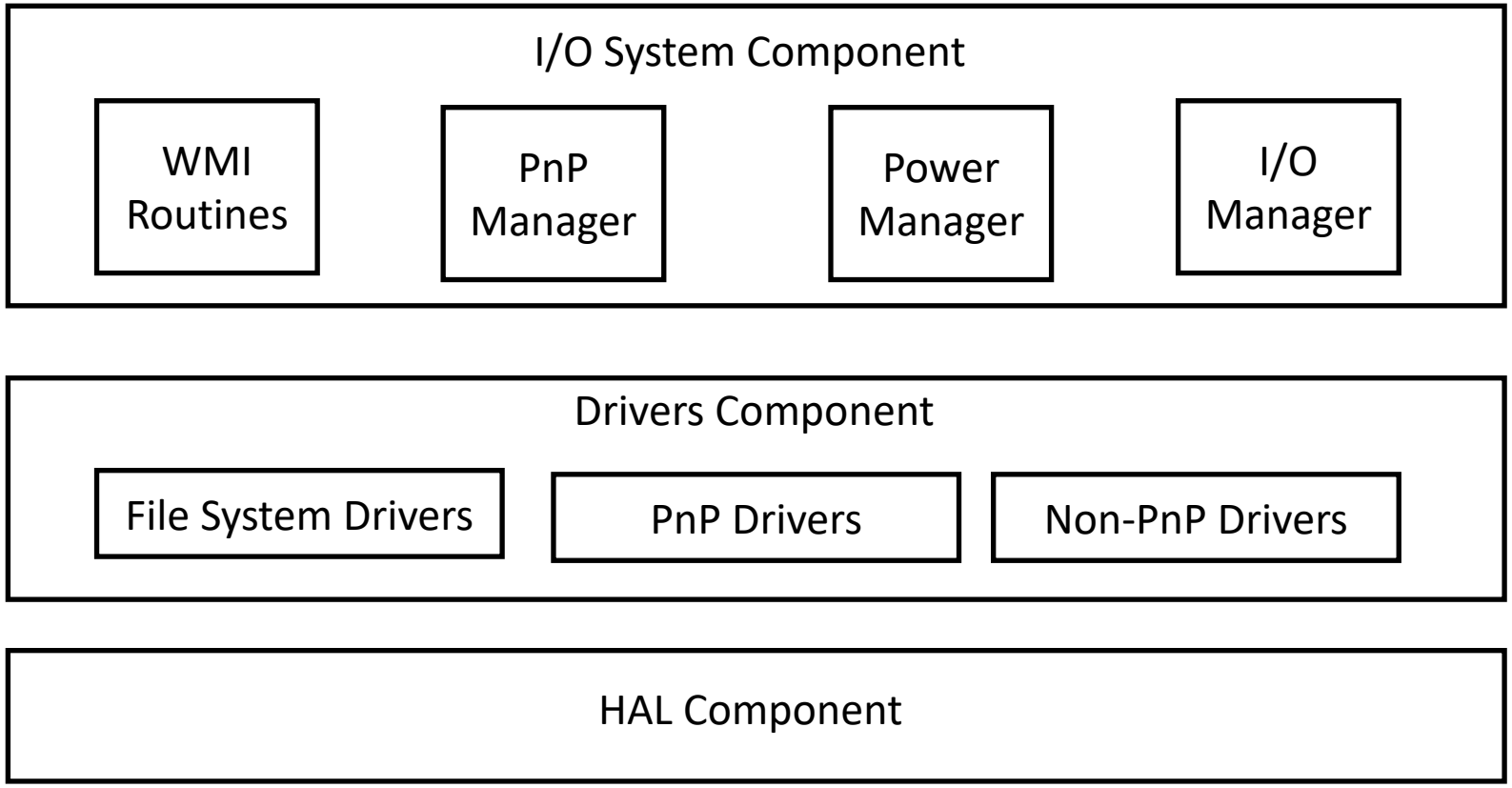
Layering

- Develop specifications at each layer of abstraction
  - *subsystem* or *component*: special-purpose division of a larger entity
    - Example: for OS, memory manager, process manager; Web store: credit card handlers
  - *subcomponent*: part of a component
    - Example: I/O component has I/O managers and I/O drivers as subcomponents
  - *module*: set of related functions, data structures

Example: Windows 10 and Windows Server 2016 I/O System

- 3 layer decomposition of components
  - I/O System Component
    - Windows Management Interface (WMI) routines
    - Plug and Play (PnP) manager
    - Power manager
    - I/O manager
  - Drivers Component
    - File system drivers
    - Plug and play drivers
    - Non-plug and play drivers
  - Hardware Abstraction Layer (HAL) component (no subcomponents)

Example: Decomposition



Example: More Details

- Subcomponents of file system drivers
  - Compact disk file system drivers (CDFS)
  - NT file system (NTFS)
  - Fast file allocation table file system (FAT)
  - Encrypting file system (EFS)
- Below this layer are module, function layers
- I/O system uses data stored in several places
  - Registry: database storing system configuration information
  - Driver installation files (INF)
  - Files storing digital signatures for drivers (CAT)

Design Document Contents

- Provide basis for analysis
  - Informal, semiformal, formal
- Must include:
  - *Security functions*: high-level descriptions of functions that enforce security and overview of protection approach
  - *External interfaces*: interfaces visible to users, how the security enforcement functions constrain them, and what the constraints and effects should be
  - *Internal design*: Design descriptions addressing the architecture in terms of the next layer of decomposition; also, for each module, identifies and describes all interfaces and data structures

Security Functions

Security functions summary specification identifies high-level security functions defined for the system; includes

- *Description of individual security functions*, complete enough to show the intent of the function; tie to requirements
- *Overview of set of security functions* describing how security functions work together to satisfy security requirements
- *Mapping to requirements*, specifying mapping between security functions and security requirements.

External Interface

High-level description of external interfaces to system, component, subcomponent, or module

1. *Component overview* identifying the component, its parent, how the component fits into the design
2. *Data descriptions* identifying data types and structures needed to support the external interface descriptions specific to this component, and security issues or protection requirements relevant to data structures.
3. *Interface descriptions* including commands, system calls, library calls, functions, and application program interfaces as well as exception conditions and effects

Example 1

- Routine for error handling subsystem that adds an event to an existing log file

Interface Name

error_t add_logevent (handle_t handle, data_t event);

Input Parameters

handle	valid handle returned from previous call to *open_log*
event	buffer of event data with records in *logevent* format

Example 1 (*con't*)

Exceptions

- Caller lacks permission to add to EVENT file
- Inadequate memory to add to an EVENT file

Effects

Event is added to EVENT log.

Output Parameters

status	status_ok	/* routine completed successfully */
	no_memory	/* insufficient memory (failed) */
	permission_denied	/* no permission (failed) */

Note

add_logevent is a user-visible interface

Example 2

- Interface for web user to change user password

Interface Name

User Manager / Change Password

Input Parameters

Old password	Current user's current password
New password	Current user's new password
Confirm new password	Current user's confirmation of new password
OK button	Used to submit change password request
CANCEL button	Used to cancel change password request and return to previous screen/window

Example 2 (*con't*)

Exceptions

- Caller does not have permission to submit change password request
- New password does not meet complexity requirements
- New password does not match confirmation password

Effects

- Event is added to EVENT log
- If current password is correct, new password and confirmed password identical, and new password meets complexity requirements, user's password is changed

Output Parameters

Dialog box indicates password is changed, or password did not meet complexity requirements, or new and confirmed password did not match

Note

User Manager / Change Password is a user-visible interface

Internal Design

Describes internal structures and functions of components of system

1. *Overview of the parent component*; its high-level purpose, function, security relevance
2. *Detailed description of the component*; its features, functions, structure in terms of the subcomponents, all interfaces (noting externally visible ones), effects, exceptions, and error messages
3. *Security relevance of the component* in terms of security issues that it and its subcomponents should address

Example: Parent Component

- Documents high-level design of audit mechanism shown previously
- Audit component is responsible for recording accurate representation of all security-relevant events in the system and ensuring that integrity and confidentiality of the records are maintained.
  - *Audit view*: subcomponent providing authorized users with a mechanism for viewing audit records.
  - *Audit logging*: subcomponent records the auditable events, as requested by the system, in the format defined by the requirements
  - *Audit management*: subcomponent handling administrative interface used to define what is audited.

Example: Detailed Component Description

- Audit logging subcomponent records auditable events in a secure fashion. It checks whether requested audit event meets conditions for recording.
- Subcomponent formats audit record and includes all attributes of security-relevant event; generates the audit record in the predefined format
- Audit logging subcomponent handles exception conditions
  - Error writing to the log

Example

- Audit logging subcomponent uses one global structure:

```
structure audit_config      /* defines configuration of */
                            /* which events to audit    */
```

- Audit logging subcomponent has two external interfaces:

```
add_logevent()              /* log an event */
logevent()                  /* ask to log event */
```

Example: Security Relevance

- Audit logging subcomponent monitors security-relevant events and records those events matching configurable audit selection criteria
  - Security-relevant events include attempts to violate security policy, successful completion of security-relevant actions

Low-Level Design

Focus on internal logic, data structures, interfaces; may include pseudocode

1. *Overview*, giving the purpose of the module and its interrelations with other modules, especially dependencies on other modules
2. *Security relevance of the module*, showing how the module addresses security issues
3. *Individual module interfaces*, identifying all interfaces to the module, and those externally visible.

Example: Overview of Module

- Audit logging subcomponent
  - Responsible for monitoring and recording security-relevant events
  - Depends on I/O system and process system components
- Audit management subcomponent
  - Depends on audit logging subcomponent for accurate implementation of audit parameters configured by audit management subcomponent
- All system components depend on audit logging component to produce their audit records

Example: Components Module Uses

- Audit logging subcomponent:

Variables

structure logevent_t	defines audit record
structure audit_ptr	current position in audit file
file_ptr audit_fd	file descriptor of audit file

Global structure

structure audit_config	defines configuration of which events are to be audited

External interfaces

add_logevent()	begin logging events of given type
logevent()	ask to log event

Example: Security Relevance of Module

- Audit logging subcomponent monitors security-relevant events, records those events matching the configurable audit selection criteria
  - Example: attempts to violate security policy
  - Example: successful completion of security-relevant actions
- Audit logging subcomponent must ensure no audit records are lost, and are protected from tampering

Example: Individual Module Interfaces

- *logevent*() only non-priviledged external interface

  verify function parameters
  call *check_selection_parameters* to determine if system has been configured to audit event
  if *check_selection_parameters* then
    call *create_logevent*
    call *write_logevent*
    return success or error number
  else
    return success

Example: Individual Module Interfaces (*con't*)

- *add_logevent*() available only to privileged users

  verify caller has privilege/permission to use this function
  if caller does not have permission
    return permission_denied
  verify function parameters
  call *write_logevent* for each event record
  return success or error number from *write_logevent*

Internal Design

Show in which documents to put various designs to create a useful, readable, and complete set of documents

- *Introduction*: purpose, scope, target audience
- *Component overview*: identifies modules, data structures; how data is transmitted; security relevance and functionality
- *Detailed module designs*
  - *Module #1*: module's interrelations with other modules, local data structures, its control and data flows, security
    - *Interface Designs*: describes each interface
    - Interface 1a: security relevance, external visibility, purpose, effects, exceptions, error messages, and results

Example

- Windows I/O System
  - High-level design document describes I/O system as a whole
    - Necessary descriptions of I/O System, Drivers, HAL
  - Describes first level of design decomposition
- Next level of decomposition (here only shown for I/O System)
  - High-level design document for I/O file drivers
  - Internal design specification for HAL component
- Internal design specifications for each subcomponent of I/O file drivers

Documentation and Specification

- Time, cost, efficiency may impact how complete set of documents prepared
- Different types of specifications
  - Modification Specifications
  - Security Specifications
  - Formal Specifications

Modification Specifications

- Used when system built from previous versions or components
  - Specifications for these versions or components
  - Specifications for changes to, additions of, and methods for deleting modules, functions, components
- Developer understands the system upon which the new system is based

Security Considerations

- Security analysis must rest on specification of current system, not previous ones or changes only
  - If modification specifications are only ones, security analysis based upon incomplete specifications
  - If previous system has full security specifications, then analysis may be complete

Security Specifications

- Used when design specifications adequate except for security issues
- Develop supplemental specifications to describe missing security functionality
  - Develop document that starts with security functions summary specification
  - Expand to address security issues of components, subcomponents, modules, functions

Example: System X

- Underlying UNIX system completely specified, including complete functional specifications and internal design specifications
  - Neither covered security well, let alone document new functionality
- Team supplemented existing documentation with security architecture document
  - Addresses deficiencies of existing documentation
  - Gives complete overview of each security function
  - Additional documentation describes external interface, internal design of all functions

Formal Specifications

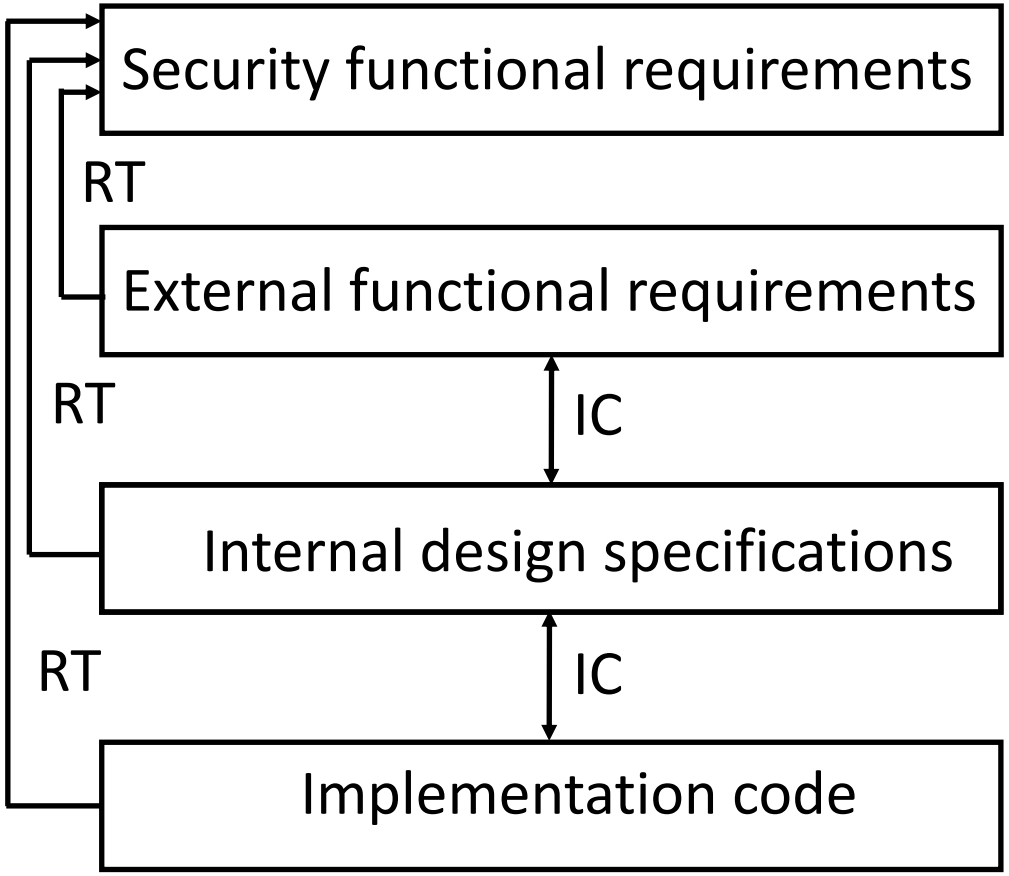
- Any specification can be formal
- Written in formal language, with well-defined syntax and sound semantics
- Supporting tools allow checking
  - Parsers
  - Theorem provers

Justifications

- Formal techniques
  - Proofs of correctness, consistency
- Informal techniques
  - *Requirements tracing*: showing which specific security requirements are met by parts of a specification
  - *Informal correspondence* (also called *representation correspondence*): showing a specification is consistent with adjacent level of specification

Requirements Mapping and Informal Correspondence

RT: requirements tracing
IC: Informal correspondence



Mappings Between Layers

- Informal techniques most appropriate when all levels of specification have identified requirements and all adjacent pairs of specifications have been shown to be consistent
  - Security functions summary specification and functional specification
  - Functional specification and high-level design specification
  - High-level design specification and low-level design specification
  - Low-level design specification and implementation code
- Doing third mapping may be difficult as difference in levels of abstraction can obscure relationship
  - Intermediate level often simplifies this

Example

- Family of specifications across several levels
- Security requirement R2 requires users of system be identified to system, and to have identification authenticated by system before use of any system functions
- Identification and authentication (I&A) high-level security-enforcing function from security functions summary specification:
    1. Users identify themselves to system using *login_ID* before they can use any system resources
    2. Users use password to authenticate their identity; system must accept password as authentic before any resources can be used
    3. Password must meet specific size, character constraints
- Interfaces *login*, *change_password* described in functional specification

Example

- Requirements mapping represented by table following explanation
  - In this example, only R2 maps to I&A
- Informal correspondence between functional, security functions summary specifications are:
  - *login* maps to items 1, 2 in description of I&A
  - *change_password* maps to items 2, 3 in description of I&A

Security requirements	**Function 1**	**I&A**	**...**	**Function *m***
R1				
R2		X		
...				
R*n*				

Informal Arguments

- Requirements tracing identifies components, modules, functions that meet requirements but not how well they are met
- *Informal arguments* uses approach similar to mathematical proofs

Example

- System W is a new version of an existing product
  - Previous version had good requirements, security functions summary, external functional, and design specifications
- System W added bug fixes, features (some large and pervasive)
- Developers created external functional specification, internal design specification documents for all modifications of the system
  - Each document defined scope to be modifications only
- Security analysts asked developers many questions
- Resulting combined security specification and analysis document addressed impacts of change on security of previous system

Example (*con't*)

- Analysis document contained
  - Security analysis document containing individual documents for each of the different functional areas
  - System overview document
  - Test coverage analysis document
- Documentation semiformal, written in natural language with code excepts where practical
  - Design overview: gave high-level description of component, relevant security issues, impact on security
  - Requirements section: identified security functionality in module, traced it to applicable security functional requirements
  - Interface analysis: described new or impacted interfaces, mapped requirements to them, identified and documented security problems and made recommendations

Formal Methods

- Requirements tracing checks specifications satisfy requirements
- Specifiers intend to process specification using automated tools
  - Proof-based technology typically based on some form of logic (like predicate calculus); user constructs proof, proof checkers validate it
  - Model checking takes a security model and processes a specification to determine if it meets the model's constraints

Reviews of Assurance Evidence

- Reviewers given guidelines for review
- Other roles:
  - Scribe: takes notes
  - Moderator: controls review process
  - Reviewer: examines assurance evidence
  - Author: author of assurance evidence
  - Observer: observe process silently
- Important: managers may *only* be reviewers, and only then if their technical expertise warrants it

Setting Review Up

- Moderator manages review process
  - If not ready, moderator and author's manager discuss how to make it ready with author
  - May split it up into several reviews
  - Chooses team, defines ground rules
- Technical Review
  - Reviewers follow rules, commenting on any issues they uncover
    - May request moderator to stop review, send back to author
  - General and specific comments to author

Review Meeting

- Moderator is master of ceremonies
  - Grammatical issues presented first
  - General and specific comments next
  - Goal is to collect comments on entity, *not* to resolve differences
  - Scribes write down comments and who made it (anyone can see it, help scribe, verify comment made)

Conflict Resolution

- After meeting, scribe creates Master Comment List
  - Reviewers mark “Agree” or “Challenge”
  - All comments that everyone “Agree”s are put on Official Comment List (OCL)
  - Rest must be resolved by reviewers
- Moderator, reviewers then:
  - Accept as is
  - Accept with changes on OCL
  - Reject

Conflict Resolution

- Author takes OCL, makes changes as sees fit
- Author then meets with reviewers
  - Explains how each comment made by reviewer was handled
  - All must be resolved to satisfaction of author, reviewer
- Review completed

Informal Review

- Occurs sometimes due to quick pace of releases, bug fixes
  - Review process does not include moderator or scribe
  - Review may use electronic communications with one reviewer