

COMP5900 OS SECURITY

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1 Introduction

- trusted computing base
 - applications that are essential to functioning of the OS
 - e.g., passwd
 - these would probably be okay to talk about for OS vuln. but kernelspace code is preferred

1.1 Bloom's Taxonomy

- course targets top 3 sections (for evaluation)
 - create
 - evaluate
 - analyze
 - (some understanding)

1.2 What is an OS?

- kernel
- essential applications (systemd, passwd, etc.)
- what does it do?
 - scheduling
 - network stack
 - file systems
 - block I/O on disk
 - hardware interrupts (e.g. I/O)
 - at least basic access control (memory protection, etc.)
 - often runs in supervisor mode (apparently not necessarily? But I don't agree with this...)

1.3 What is the Most Secure OS?

- probably something task-specific

1.4 Group Activity: Come up with an OS-less implementation for a word processor

- interrupt handling for keyboard
 - need at least some basic scheduler that can pause and resume main execution
- interface with monitor for graphical display
- block I/O driver for disk
 - filesystem to organize data
- hmm... this is starting to feel like we just implemented our own task-specific OS
 - that's the main takeaway here!

2 Secure OS

2.1 Van Oorschot Chapter 5.0 - 5.2

2.1.1 Intro

- early security had same challenges we face today
 - protecting programs from others
 - restricting access to resources
 - “protection” means mostly memory access control
- memory is important
 - holds data
 - holds programs
 - I/O devices through memory address and files
 - files -> both main memory and secondary storage
- early protection
 - virtual addresses
 - access control lists
 - limited process address space
 - these fundamentals are still used today
- Multics
 - security very influential in its early design
 - original UNIX was heavily based on Multics

2.1.2 Memory protection, supervisor mode, and accountability

- batch processing
 - prepare jobs ahead of time and submit them together as a batch job
- time-sharing systems
 - allowed shared use of a single computer
 - (preferable to batch jobs from a usability standpoint)
 - same way single-user computers work today with one user running many programs
- resource conflicts
 - processes running simultaneously can try to access the same resources

- ▶ intentionally or otherwise
- ▶ if a program could access full memory of the machine, errors could corrupt OS data or code
- supervisor
 - ▶ runs with higher permissions in the protection CPU (ring 0, 1, 2)
 - ▶ no other program can alter the privileged bit
 - ▶ a special machine instruction immediately transfers control to the supervisor
- privileged bit
 - ▶ process is running in supervisor mode
- descriptor register
 - ▶ holds a memory descriptor that describes base and upper bound
 - ▶ lowest addressable memory by a process and a number of words from that point that are addressable
- limitations of memory-range based protection
 - ▶ all-or-nothing mode of control
 - ▶ either you have full access or no access
 - ▶ allows full isolation, but not fine-grained sharing
- segment addressing with access permissions
 - ▶ segment = collection of words representing a logical unit of information
 - ▶ descriptor segment per process maintained by OS
 - holds segment descriptors that define addressable memory and permissions
 - ▶ descriptor base register points to memory descriptor of active process
- permissions on virtual segments
 - ▶ R non-supervisor can read
 - ▶ W can be written to
 - ▶ X can be executed
 - ▶ M run in supervisor mode (if X)
 - ▶ F all access attempts trap to supervisor
 - ▶ now the same physical segment can be given different access for different processes
- accountability, UIDs, and principals
 - ▶ UID (maps users to a unique identifier)
 - ▶ “principal” -> abstracts the entity responsible for code execution from the actual user or program actions
 - ▶ UID is the primary basis for granting permissions
- roles
 - ▶ assign distinct UIDs to distinct privileges
 - ▶ should follow principle of least privilege

2.1.3 Reference monitor, access matrix, security kernel

- reference monitor
 - ▶ concept that “all references by any program to any other program, data, or device are validated”
 - ▶ conceptualized as one reference monitor, but in practice, would be a lot of reference monitors working together

- access matrix
 - 2D matrix of subjects, objects
 - taking a row (subject) gives a capabilities list
 - taking a column (object) gives an access control list
 - each intersection in this matrix defines a set of permissions
- security kernel
 - reference validation
 - audit trails via audit logs (user X did Y at time Z)
 - these might not necessarily need to be tamper-proof, depends on needs
 - needs to be:
 - tamper-proof
 - always invoked (not circumventable)
 - verifiable (needs to be minimal / small enough to make this possible)
- protection mechanisms
 - ticket-oriented (capabilities)
 - access token allows entry to an event, as long as ticket is authentic
 - id-based
 - authorization lists based on ID

2.2 Jaeger Chapter 1

- general-purpose -> complex
- task-specific -> not so complex
- general purpose OS are hard to secure because of their complexity
- ensuring security depends on securing
 - resource mechanisms
 - scheduling mechanisms

2.2.1 Secure OS

- enforce security goals despite the threats faced by the system
 - implement security mechanisms to do this
- secure OS possible?
 - probably not
 - a modern OS by definition can probably never be 100% secure
 - security as a negative goal
- understanding secure OS requires understanding
 - security goals
 - trust model
 - threat model

2.2.2 Security Goals

- define operations that can be executed by a system while remaining in a secure state
 - i.e. prevent unauthorized access

- high level of abstraction
- define a requirement that the system's design can then satisfy
- we want to maintain: secrecy, integrity, availability
 - secrecy = limit read access for objects by subjects
 - integrity = limit the write access for objects by subjects
 - availability = limit the resources that a subject may consume (i.e. no DoS)
- subjects
 - users, processes, etc.
- objects
 - resources of the system that subjects may or may not access in various ways
 - e.g. files, sockets, memory
- security goals can be
 - defined by function (e.g. principle of least privilege)
 - defined by requirements (e.g. simple-security property)

2.2.3 Trust Model

- trust model
- trusted computing base

2.2.4 Threat Model

2.3 Jaeger Chapter 2

2.3.1 Protection System

2.3.2 Reference Monitor

2.3.3 Secure Operating System Definition

2.3.4 Assessment Criteria