Week 4

MIS-5903

Domain 3:

Security Architecture & Engineering

https://community.mis.temple.edu/mis5903sec711summer2021

Last Revised 6/01/21

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ISO/IEC 42010:2011 Vocabulary

- Architecture
  - Organization of a system/components
  - Relationship between components and environment
  - Principles guiding design and evolution
- Architecture Description (AD) – documents in a formal manner
- Stakeholder - have interests in the system
  - Users
  - Maintenance staff, operators
  - Developers
  - Suppliers
- View – Representation of system from perspective of concerns
- Viewpoint -
  - Specification of the conventions for constructing and using a view
  - Template from which to develop individual views (purposes, audience for a view, techniques)

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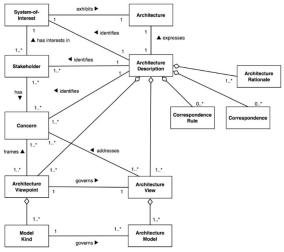
Example Viewpoints

- Logical
- Physical
- Structural
- Behavioral
- Management
- Cost
- Security



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Central Processing Unit

- Registers (locate instructions, data in memory)
  - General – variables, temporary work results
  - Special – program counter, stack pointer, program status word
    - User Mode (aka problem state)
    - Privileged Mode (aka kernel or supervisor)
- Control Unit
  - Control Bus
  - Data Bus (retrieve data)
  - Address Bus (pass from CPU to RAM, ROM, I/O)
- Arithmetic Logit Unit (ALU)
- Multi-tasking – processor completes individual tasks
- Multiprocessing
  - Symmetric mode (scheduler determines and balances processor loads)
  - Asymmetric mode (dedicated processor for user time-sensitive threads)

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Memory – Random Access Memory (RAM)

- Static RAM – does not require refreshing; used for cache.
- Dynamic:
  - Synchronous DRAM – synchronized signal input and output
  - Extended Data Out DRAM – access next block of data ("look ahead")
  - Burst EDO SDRAM – reads and sends up to four memory addresses.
  - Double Data Rate SDRAM – utilizes both rising and falling cycles of a clock pulse

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Memory – Other Types

- Read Only Memory
  - Software stored in ROM referred to as firmware
  - Programmable Read-Only Memory (only once)
  - Erasable Programmable Read-Only Memory (EPROM) – ultraviolet
  - Electrically Erasable Programmable Read-Only Memory (EEPROM)
- Flash Memory
  - SD-Card is an example
- Cache Memory
  - Level 3 on motherboard
  - Level 1, Level 2 inside processor/controller.

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Memory Issues

- Mapping
  - Physical memory is an absolute address
  - Indexed addresses used by software are logical addresses.
- Buffer Overflow
  - Programmer doesn't check input value type
- Memory Leaks
  - Operating System becomes "starved"
  - Memory no longer in use/needed not released.

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Operating Systems

- Process Management
  - Cooperative multitasking (Windows 3.x, early Mac) – controlled by process
  - Preemptive multitasking – controlled by operating system
- Thread Management – portions of process
- Process Scheduling – affinity levels
- Process Activity
  - Process isolation
  - If not encapsulated, could accept malicious instructions
  - Time Multiplexing – processes use same resources

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Operating System Memory Management

- Goals:
  - Provide abstraction level for programmers
  - Maximize performance with limited memory
  - Protect OS and applications in memory
- Relocation: swap from RAM to hard drive. Provide Pointers
- Protection: limit processes to assigned memory segments
- Sharing: allow shared memory segments
- Logical Organization: Segment all memory types
- Physical Organization: Separate memory space for OS versus apps.

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Input/Output Device Management

- Interrupts
  - Programmable I/O – checks for device
  - Interrupt-Driven I/O – waits for subsequent request
  - I/O using Direct Memory Access (DMA) – DMA controller (unmapped I/O)
  - Premapped I/O – I/O device provided memory address of requesting process
  - Fully Mapped I/O – Operating System acts as broker.

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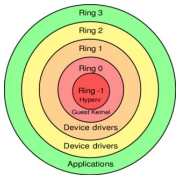
CPU Architecture



- Ring 3 – Applications
- Ring 2 – Operating system utilities, File system drivers
- Ring 1 – Operating System
- Ring 0 – Operating system Kernel
- Ring -1 – Virtualized Environments

- Available Ring(s) Determined by CPU

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Operating System Architectures

- Monolithic – all processes run in kernel mode
- Layered
- Microkernel – core processes run in kernel mode; remaining processes run in user mode.
- Hybrid microkernel – All operating system processes run in kernel mode. Processes divided between microkernel or client/server model.

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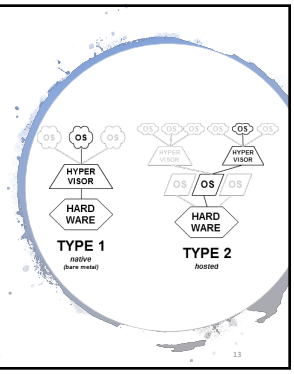
Virtualization

- Type 1 – Vmware ESXi, Microsoft Hyper-V
- Type 2 – VirtualBox, VMWare Workstation, Vmware Fusion, Virtual PC



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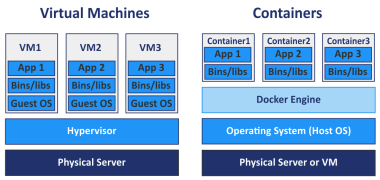
Another Virtualization Option - Containers

- Container contains the application, as well as any of its dependencies to run that are outside of the operating system.
- Docker is a common example of Containerization



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Security Policy

- Access Control
- Least Privilege
- Separation of Duties (SoD)
  - More than one person required to complete a task
- Auditing
- Trusted Paths
- Does not contain covert channels

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Access Control

- Mandatory Access Control – based on discrete levels
- Role Based Access Control – based on roles
- Discretionary Access Control – set at the resource (not necessary tied to role)
- Content Based Access Control – based on the sensitivity of data
- Context Based Access Control – based on the sequence of events or other factors

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Trusted Computer System Evaluation Criteria (TCSEC)

Trusted computing Base (TCB)

- Collection of all hardware, software, and firmware within a system that provides security and enforces security policy.

Security Perimeter

Reference Monitor

Security Kernel

- Hardware, software, and firmware that fall within the TCB

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Security Models – Bell-LaPadula

First mathematical model of a multilevel security policy

Confidentiality Focused

Simple Security Rule – cannot read data at higher security levels (no read up)

* (star) property rule – cannot write lower levels (no write down)

Strong Star property rule – to be able to read and write, subject and object must be equal.

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Security Models – Biba

- Set of access rules designed to ensure data integrity
- Simple Integrity – subject cannot read data at lower levels (no read down)
- * (star) integrity axiom – subjects cannot modify objects at higher integrity level (no write up)

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Security Models – Clark-Wilson

Protect the integrity of data and ensure properly formatted transactions

Three goals of integrity:

- Subjects can access objects only through authorized programs (access triple)
- Separation of duties is enforced
- Auditing is required.

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Security Models – Others

- Noninterference – multilevel security model states that commands and activities performed at one level should not be seen by, nor affect subjects or objects at other security levels.
- Brewer-Nash – dynamically changing access controls protect against conflicts of interest. (also known as Chinese Wall)
- Graham-Denning – model shows how subjects and objects should be created and deleted. Addresses how to assign specific access rights.
- Harrison-Ruzzo-Ullman – model shows how a finite set of procedures can be available to edit the access rights of a subject.

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Systems Evaluation – ISO/IEC 15408 (CC)

- Common Criteria has seven assurance levels
  - EAL1 – Functionally tested
  - EAL2 – Structurally tested
  - EAL3 – Methodically tested and checked
  - EAL4 – Methodically designed, tested, and reviewed
  - EAL5 – Semi formally designed and tested
  - EAL6 – Semi formally verified design and tested
  - EAL7 – Formally verified design and tested

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Common Criteria Components

- PP - Protection Profile – request for a specific solution
- TOE - Target of Evaluation – proposed product
- ST – Security Target – vendor's written explanation
- Security functional requirements – individual security functions provided by the product
- Security assurance requirements – measures taken during development and evaluation of product to ensure compliance with claimed functionality
- Packages – What must be achieved to achieve specific EAL.

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Certification versus Accreditation

- Certification tests and documents good and bad results
- Accreditation is the formal acceptance of the system
- Requirement of Federal Information Security Management Act of 2002 (FISMA)
- "Authorization to Operate"
- Major Changes require re-certification, and thus re-accreditation

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Open versus Closed Systems

- Open systems are built upon standards, protocols, interfaces that have published specifications
  - Windows, OS X, Linux, Unix
- Closed Systems do not follow industry standards
  - Proprietary

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Parallel Computing (Parallelism)

- Bit-Level– each bit processed separately through parallel gates
- Instruction-Level – two or more instructions executed simultaneously (multi-core)
- Task-Level – divide the program into tasks or threads and run in parallel
- Data – distribute data among different nodes to process in parallel

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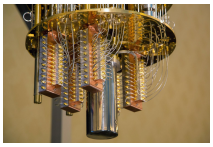
New Technologies – Quantum Computing



- IBM and others developing this technology.
- Quantum states
  - Superposition
  - Entanglement
- Instead of binary (0 or 1), a quantum bit is "fluid" / "on the spectrum"
- Sample Applications:
  - Encryption
  - Healthcare – Medication Development
  - Future Quantum Internet

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Industrial Control Systems

- NIS 800-82 "Guide to Industrial Control Systems (ICS) Security
- Programmable Logic Controllers
- Distributed Control Systems
- Supervisory Control and Data Acquisition (SCADA)
  - Remote Terminal Unit (RTU) (endpoint)
  - Data Acquisition Servers (back ends)
  - Human-Machine Interface (user station, displays interface)

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Cyber Physical Systems

Embedded Systems

Digital thermometers, other specialized devices

Internet of Things

Global network of connected embedded systems
Each device is uniquely addressable
Issues to address:

- Authentication
- Encryption
- Updates

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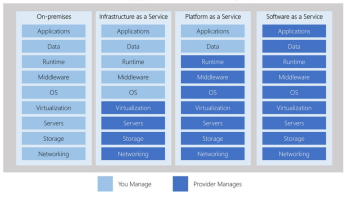
Cloud Computing

- SaaS – Software as a Service – ready to use application
- PaaS – Platform as a Service – Operating system, Database Engine, etc., but not a ready-to-use application
- IaaS – Infrastructure as a Service – full access to the underlying system; full responsibility for the customer



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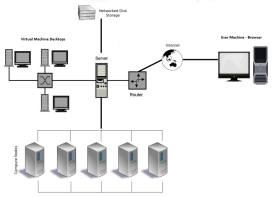
High Performance Computing (HPC)

- Utilization of multiple computers to achieve more as a group than individually.
- Orchestrator / Controller



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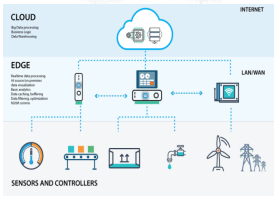
Edge Computing

- Refers to Topology
- Derived from Content Delivery Networks
  - Web and video – closer to users
- Low latency close to the requests



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Mobile Security

- False base stations can be created
- Confidential data can be stolen
- Camera and/or microphones can capture data
- Internet sites accessed in violation of policies
- Malicious code downloaded
- Encryption can be weak, not end-to-end.

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System Attacks

Maintenance Hooks

Type of back door
Used during development
Should be removed

Time-of-Check/Time-of-Use

Race Condition – attacker makes processes execute out of sequence to control the result

TOCTOU – attacker jumps in between two tasks, modifies the temporary value to control the result

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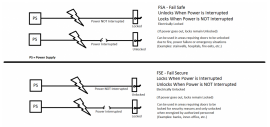
Failure Modes



- Fail Open – "fail safe"
- Fail Closed – "fail secure"

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Site and Facility Threats

- Natural environmental – floods, earthquakes, storms, tornadoes, fires, temperature
- Supply system – power distribution outages, communication interruptions, also water, gas, air filtration, etc.
- Manmade – unauthorized access (internal or external), explosions, damage by disgruntled employees, employee errors, accident, vandalism, fraud, theft, etc.
- Politically motivated threats – strikes, riots, civil disobedience, terrorist attacks, bombings, etc.

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Physical Security Program

- Deter crime and disruption – fences, security guards, signs
- Reduction of damage by delaying – layered defenses, locks, security personnel, barriers
- Detection – smoke or motion detectors, CCTV
- Incident assessment – security guards dispatched
- Response procedures – internal as well as outside security professionals

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Building the Program

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Building a Facility

- Combustibility (wood, steel, concrete)
- Fire Rating
- Walls – Reinforcement for secured areas

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Building a Facility - Doors

- Resistance to forcible entry
- Emergency Marking
- Placement
- Locked or Controlled
- Alarms
- Secure hinges
- Directional opening
- Electric door locks (fail safe)
- Type of glass – shatterproof or bulletproof
- Hollow-Core or Solid-Core

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Building a Facility – Ceilings & Floors

- Weight-bearing rating
- Drop Ceilings
  - "true floor" to "true ceiling"
- Floors - Nonconducting surface and material

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Building a Facility – Windows

- Translucent or opaque
- Alarms
- Placement
- Accessibility to intruders
- Strength - Shatterproof?
  - Standard
  - Tempered
  - Acrylic
  - Wired
  - Laminated
  - Solar or Security film

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Building a Facility – HVAC

Positive Air Pressure

Protected intake vents

Dedicated power lines

Emergency shutoff valve and switches

Placement

Considerations:

- Computer systems: 175 degrees
- Magnetic Storage Devices: 100 degrees
- Paper Products: 350 degrees

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Designing a Facility - Supplies

Electric

- Backup and alternative power supplies
- Clean and steady power source
- Dedicated feeders to required areas
- Placement and access to distribution panels and circuit breakers
- Electromagnetic Interference (EMI)
- Radio Frequency Interference (RFI)
- UPS / Online UPS / Generators

Water & Gas

- Shutoff valves – labeled for visibility
- Positive flow (material flows out of building)
- Placement – properly located

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Electric Power Fluctuations

Excess:

- Spike – momentary high voltage
- Surge – prolonged high voltage

Loss:

- Fault – momentary
- Blackout – prolonged, complete loss

Degradation:

- Sag/Dip – momentary – from one cycle to a few seconds
- Brownout – prolonged below normal voltage
- In-Rush current – initial surge required to start a load

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Designing a Facility – Fire Detection & Suppression

- Placement of sensors and detectors
  - Smoke
  - Heat / Rate of Rise
- Placement of suppression systems
- Type of detectors and suppression agents

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Fire Suppression

Class	Type of Fire	Elements	Suppression
A	Common combustibles	Wood products, paper, and laminates	Water, foam
B	Liquid	Petroleum products and coolants	Gas, CO2, foam, dry powders
C	Electrical	Electrical equipment and wires	Gas, CO2, dry powders
D	Combustible metals	Magnesium, sodium, potassium	Dry powder

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Substance Interactions

Combustion Element	Suppression Method	How Suppression Works
Fuel	Soda acid	Removes fuel
Oxygen	Carbon dioxide	Removes oxygen
Temperature	Water	Reduces temperature
Chemical combustion	Gas – Halon substitute (FM-200)	Interferes with the chemical reasons between elements

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Fire Suppression

Turn off HVAC

- Reduces oxygen
- Minimizes spread of smoke

Sprinklers

- Wet pipe
- Dry pipe
- Preaction
- Deluge – large volume of water

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Next Steps

Complete Discussion Questions / Participation

Complete online quiz – (graded)

Complete Domain #3 Practice Exam (submit best result)

Begin Week 5 Reading

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