Session 01

Introduction to Systems Security

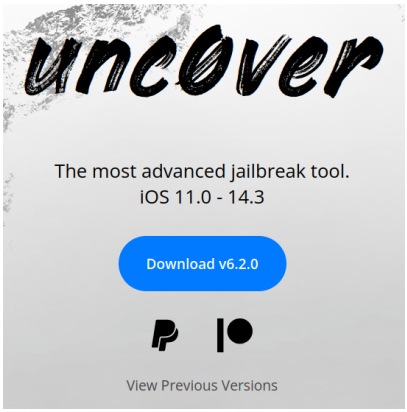
Security of Information Systems (SIS)

Computer Science and Engineering Department

October 4, 2023

Notes

iOS Jailbreak: unc0ver



https://unc0ver.dev/

Notes

History of OWASP Top 10

`https://www.hahwul.com/cullinan/history-of-owasp-top-10/`
2021, 2017, 2013, 2010, 2007, 2003
The more things change, the more they stay the same.

- Injection (3, 1, 1, 1, 2, 6)
- XSS (-, 7, 3, 2, 1, 4)
- Broken Authentication and Session Management (7, 2, 2, 3, 7, 3)
- Security Misconfiguration (5, 6, 5, 6, -, -)

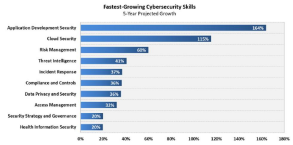
Notes

Cybersecurity Jobs

- `https://cybersecurityventures.com/jobs/`
- *350 percent growth in open cybersecurity positions from 2013 to 2021*
- *3.5 million unfilled cybersecurity jobs globally by 2021, up from one million positions in 2014*

Notes

Cybersecurity Skills



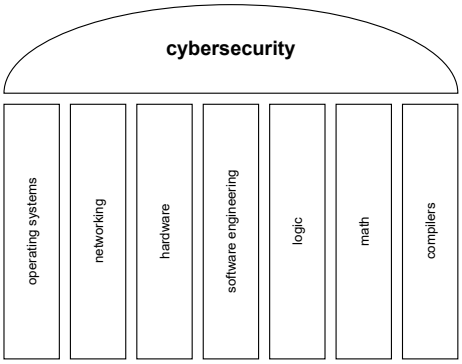
Based on the Burning Glass analysis of employer demand in postings, the skills projected to grow fastest in the next five years are:

Skill	5-Year Projected Growth	Postings Oct. 2019-Sept. 2020	Salary Premium
Application Development Security	164%	29,635	$12,266
Cloud Security	115%	19,477	$15,025
Risk Management	60%	57,967	$13,379
Threat Intelligence	41%	60,039	$9,609
Incident Response	37%	23,497	$9,693
Compliance and Controls	36%	54,770	$12,423
Data Privacy and Security	36%	88,527	$5,256
Access Management	32%	110,096	$6,451
Security Strategy and Governance	20%	82,952	$7,735
Health Information Security	20%	413,687	$738

https://www.forbes.com/sites/louiscolumbus/2020/11/01/what-are-the-fastest-growing-cybersecurity-skills-in-2021/

Notes

System / Application Cybersecurity



Notes

Papers

- Reflections on Trusting Trust: https://dl.acm.org/doi/10.1145/358198.358210
- Understanding the Mirai Botnet: https://www.usenix.org/conference/usenixsecurity17/technical-sessions/presentation/antonakakis

Notes

Systems Security

- IT security, cyber security, computer security
- applications, operating system, infrastructure, networking
- hardware, software, information

Notes

Security of Information Systems

- focus on computer, operating system, software stack and infrastructure security
- little focus on networking, crypto, hardware
- research focus

Notes

Topics

- authentication, authorization
- attack, mitigation, bypass
- isolation, sandboxing
- fuzzing, symbolic execution
- defensive programming
- software analysis, verification and validation

Notes

Systems Security Research

- research: more on finding the right question, than the right answer
- not boring, but uncertain
- high risk, high impact
- secure build, attack, defend, repeat
- actual systems: software, hardware, infrastructure

Notes

Systems Security Research Venues

- big four: IEEE S&P (Oakland), ACM CCS, NDSS, Usenix Security Symposium
- ESORICS, RAID, ACSAC
- AsiaCCS, CNS, ACNS
- `http://faculty.cs.tamu.edu/guofei/sec_conf_stat.htm`
- `http://s3.eurecom.fr/~balzarot/notes/top4_v1/`

Notes

Research Results

- white papers: company product information
- workshops: preliminary work, networking
- conferences: complete work, novel results, networking
- journals: aggregated work, archive
- CVEs
- features in existing products
- start ups
- public / open source

Notes

Resources

- content website: `http://elf.cs.pub.ro/sis/`
- discussions, feedback: `https://curs.upb.ro/`
- MS Teams
- CTF platform: `https://sis-ctf.security.cs.pub.ro/`
- VM: `https://ocw.cs.pub.ro/courses/cns/resources/vm`

Notes

Logistics

- lecture: Wednesday, 4pm-6pm, PR706
- labs
  1. group 1: Wednesday, 6pm-8pm, EG403
  2. group 2: Tuesday, 8pm-10pm, PR706
- first lecture takes place on Wednesday, October 4, 2023, 4pm-6pm
- first lab (group 1) takes place on Wednesday, October 4, 2023, 6pm-8pm
- first lab (group 2) takes place on Tuesday, October 10, 2023, 8pm-10pm

Notes

Team

- Rareș Visalom
- Răzvan Deaconescu

Notes

Typical Lecture Session

- lecture + discussions
- research insights, trends
- demos, highlights
- DO ask questions, DO take part in discussion, DO challenge ideas, DO rebut ideas, DO open interesting topics (covering systems security)

Notes

Typical Lab Session

- lab/practical focused on problem solving, on approaches, not on tools
- CTF-like activity in lab: have problem, find solution
- challenge focused, not tutorial focused
- need focus, patience and perseverence
- we expect you to know the basics of: Linux/command line, network protocols and infrastructure, programming, assembly language, operating systems

Notes

CNS vs. SIS

- focus on offensive/exploiting vs focused on a building, attacking, defending
- narrow, focused, practical vs. diverse, holistic, conceptual
- binary/runtime application security vs. systems security
- engineer-centric vs. research-centric
- well-known steps vs. trends and models
- skill vs. approach

Notes

Grading

- 2p: lab activity
- 4p: assignments/projects (bonuses included)
- 4p: final exam (oral exam)
- lecture activity as a bonus (DO take part in lectures, see live and offline quizzes and surveys)

Notes

Contents

1. Introduction to Systems Security
2. Authentication and Password Management
3. Exploiting. Part 1: Applications
4. Exploiting. Part 2: Web & OS
5. Defense and Mitiation
6. Modern Offensive and Defensive Solutions
7. Application Confinement
8. System Isolation
9. Code Analysis
10. Fuzzing. Symbolic Execution
11. Information Flow Security
12. Software Verification

Notes

Storyline

- we have a system/infrastucture
- one way to attack it is to crack or abuse authentication
- assuming valid entry points (i.e. authentication) are secure, the attacker looks for security holes (i.e. vulnerabilities)
- the attacker exploits vulnerabilities, we use defensive mechanisms, the attacker tries to bypass them
- we assume attacks are unavoidable, we aim to confine them; we confine applications
- since applications interact with other applications and system components, we isolate the system
- proper isolation relies on separation and marking roles and validating the information flow

Notes

Storyline (cont.)

- ideally, our application or system will be secure by specification, design, implementation, validated offline
- we use static analysis and dynamic analysis (including fuzzing and symbolic execution) to validate an application offline
- a thorough approach is to use (semi)formal validation on application specifications and build it securely from those

Notes

Prerequisites

- good understanding of operating systems
- good Unix/Linux command line abilities
- good C programming skills
- fair knowledge of C shell scripting
- fair knowledge of Unix/Linux development tools
- basic understanding networking
- basic knowledge of computer architecture and assembly language

Notes

Covering Missing Know-How

- Linux/command line: USO labs: `http://ocw.cs.pub.ro/courses/uso`
- networking: RL labs: `http://ocw.cs.pub.ro/courses/rl`
- assembly: `http://ocw.cs.pub.ro/courses/iocla`
- operating systems: `http://ocw.cs.pub.ro/courses/so`

Notes

Attacker Perspective

- attacker goals
- attacker arsenal: threat model
- attacker steps: attack vector

Notes

System Model

- application control flow graph
- applications + configuration + hardware
- privileges level
- input (and output)

Notes

Scenarios

- attack iOS Device
- attack social network
- attack bank website
- attack national power grid

Notes

Defender Actions

- prevent
- isolate
- react & mitigate

Notes

Scope

- application
- operating system
- hardware
- I/O
- networking, infrastructure

Notes

Security Objectives

- privacy
- safety
- anonimity
- integrity
- confidentiality
- availability

Notes

Security vs. Safety

- safety is state
- security is process
- safety is outcome of a secure process/procedure
- security: umbrella, safety: warm and not getting wet

Notes

Trust

- validation among parties
- chain of trust: bottom-up trust
- trust anchor
- certificate chain, digital signature, certification authority

Notes

A*

- authentication: letting an entity be part of the system
- authorization: providing privileges to a given entity (subject) for resources (object)
- access control: checking whether subject can access object
- audit: inspecting action history, validating behavior

Notes

A* commands

- authentication: `login`
- authorization: `chmod`
- access control: `ls`
- audit: `find`, `auditd`

Notes

Least Privilege

- each subject is only provided the permissions it needs
- if it's not mandatory, ditch it
- sandboxing, isolation

Notes

Privilege Separation/Escalation

- split privileges among entities
- reduced actions for super user
- may require escalation (i.e. one subject may get priviliges from another)
  - be really careful about that
  - sudo, setuid, capabilities

Notes

Trusted Computing Base

- security-critical parts of the computer system
- bugs inside TCP compromise security
- i.e. priviliged parts of the computer system
- aim to reduce TCB

Notes

Attacker Mindset

- maximize profit
- time is on your side
- brute force may be an option
- you don't care as long as it works
- target many, get one

Notes

Attacker Objectives

- control
- cripple
- steal (information leak)

Notes

Threat/Adversarial Model

- decompose application, identify threats, determine coutermeasures
- classify possible attacker actions and attacker flow

Notes

Vulnerability

- misconfiguration, weakness
- exposes a risk that may be exploited for unintended outcome
- i.e. buffer overflow, integer overflow, unsanitized input

Notes

Exploit

- method to use a vulnerability for malicious outcome
- take advantage
- i.e. ret-to-libc, ROP, send injection code

Notes

Attack Vector

- steps/path to deliver a malicious outcome
- composed of attack steps (attack gadgets)
- usually chaining together exploits towards outcome
- i.e. SQL injection, actual real world attacks

Notes

Attack Surface

- parts of the system exposed to attacks
- entry points into system
- either valid entry points that may be used invalidly
- or invalid entry points
- goal is to reduce attack surface (think TCB)

Notes

Defender Mindset

- malicious vs. negligence
- time is limited
- proactive before reactive
- prevent
- monitor
- defense in depth

Notes

Proactive vs. Reactive

- similar to medicine, treating disease
- analyze threats beforehand
- deploy mitigation solutions
- react when sh*t happens
- have solutions in place

Notes

Defense in Depth

- multiple defense layers
- redundancy in defense
- assume one layer falls, others take its place

Notes

Phases for Defensive Mechanisms

- harden
- prevent
- confine
- treat

Notes

Harden

- analysis, enhancement
- off-line
- static, dynamic analysis
- verification and validation
- fuzzing, symbolic execution
- remove, treat **vulnerabilities**

Notes

Prevent

- make it difficult / impossibile for exploits to happen
- on-line, during runtime
- i.e. ASLR, DEP, stack guard, ASan

Notes

Confine

- when sh*t happens, reduce damage
- limit resources use, limit interface
- as reduced privileges as possible
- ideally customed (tailored) per app/system
- sandboxing, virtualization, access control

Notes

Treat

- if sh*t happens, solve it
- remove threat, remove damaged resources
- replace components
- apply lessons learned

Notes

Monitor

- know when sh*t happens ASAP
- proper monitoring levels; otherwise you ignore it
- monitor as much as you can
- key for availability

Notes

Keywords

- systems security
- Security of Information Systems
- goals
- safety
- trust
- trusted computing base
- least privilege
- threat model
- vulnerability
- exploit
- attack vector
- attack surface
- defense in depth
- harden
- prevent
- confine
- treat
- monitor

Notes

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