Security Testing (Introduction)

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Course Introduction

- Security Testing
  - Thursday @ 9:50, room M-V
- Grades
  - 30% be prepared – exercises throughout the semester
  - 30% multiple choice test (at the end of the semester)
  - 40% project: 20 min. presentation (OK, partially, not OK)
- Slides and projects available on the web page
- Contact
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Course topics (tentative)

1. Security Testing (Introduction)
2. Know your enemy
   Passwords - guessing and brute-forcing
3. Passive Reconnaissance and OSINT
4. Active Reconnaissance
   Pass-the-Hash
5. Privilege escalation, Pivoting and Persistence
6. Web and Mobile Application Testing
7. Threat Modeling
8. Vulnerability Scanning and Compliance
9. Social Engineering
   Kerberos
10. Red Teaming

Why – the importance of security testing

Motivation

- compliance (examples):
  - laws (EU regulations – Digital Operational Resilience Act)
  - industry standards (PCI-DSS)
  - 3rd party requirements (SWIFT)
- risk assessment (IT, operational, fraud, etc.)
- assess the security posture or cyber resilience

Compliance examples – laws

Vyhláška č. 493/2022 NBÚ o audite kybernetickej bezpečnosti, príloha č.1:

- Minimálne náležitosti žiadosti o vykonanie auditu kybernetickej bezpečnosti bod 4. *Zoznam informačných systémov a ich klasifikácia s väzbou na základnú službu a pre každý z nich najmenej informácie o informačnom systéme a*

  ...

  h) správa z posledného penetračného testovania informačného systému, použitá metodika a rozsah testovania a doloženie kvalifikácie zamestnancov vykonávajúcich penetračné testy, ak sú penetračné testy vykonané

Compliance examples – EU regulations

EU regulation 2022/2554 on digital operational resilience for the financial sector

- *In order to achieve a high level of digital operational resilience . . . financial entities should* ***regularly test*** *their ICT systems and staff having ICT-related responsibilities with regard to the effectiveness of their preventive, detection, response and recovery capabilities, to uncover and address potential ICT vulnerabilities.*
- threat-led penetration testing (TLPT)
  a framework that mimics the tactics, techniques and procedures of real-life threat actors perceived as posing a genuine cyber threat, that delivers a controlled, bespoke, intelligence-led (red team) test of the financial entity's critical live production systems

Compliance examples – industry standards and 3rd party requirements

PCI DSS 4.0.1 (2024) Requirement 11: Test Security of Systems and Networks Regularly

- 6 sections for this requirement
- informally: processes, wireless access, vulnerabilities, penetration testing, network IDS, file integrity, integrity of payment pages

Swift Customer Security Controls Framework v2025

- 7.3A Penetration testing
  Validate the operational security configuration and identify security gaps by performing penetration testing.

Why – the importance of security testing

More practical view

- ensure security controls are working as intended
- security controls have assumptions, verify they (still) hold
- finding gaps in the defense mechanisms, vulnerabilities, weak spots, missing controls
- verify the efficiency of incident detection and response
- assess employees security habits
- *real demonstration of a security problem can be very persuasive*

What – the scope

People & **Process** & **Technology**

- software (information systems)
  - often custom web application, mobile application, APIs etc.
- IT infrastructure
  - networks – DMZ, WLAN, cloud, ...
  - HW and SW IT components – network devices, servers, endpoints, ...
  - services – AD, VoIP, remote access, ...
- security controls – firewalls, IDS/IPS, AV/EDR[1], access controls, PAM, etc.
- administrative security controls – policies, procedures (incident handling)
- people – awareness, skills, ...

[1] Endpoint Detection and Response

How – different types of security testing

- Software testing
  - (ISO/IEC 25010) System and software quality models
  - security is one of the quality characteristics
  - find vulnerabilities in software (ideally before deployment, part of SDLC)
  - code review, static and dynamic analysis, fuzzing, etc.
- Vulnerability scanning/assessment
  - identify known vulnerabilities in COTS components
  - missing updates, configuration weaknesses
  - automation
  - remove false positives, interpret results

How (cont.)

- Penetration testing
  - simulating an attack on defined target
  - usually a standard methodology is followed
  - testing all relevant vectors
- Red Teaming
  - goal oriented, specific objectives
  - wide range of techniques and their combination
  - single path to success is enough
- Risk assessment
  - high-level assessment of threats and vulnerabilities
  - probability and impact
- Testing design/architecture – threat modeling
- ...

Organizational details

Know/clarify in advance

- internal or external
- white/gray/black-box
- limits, rules, expected outputs

Why, What and How $\Rightarrow$ different techniques, tools, skills, requirements, etc.

Pentesting standards, methodologies, and frameworks

- usually focused more on process than methods and techniques
- some are more useful (OWASP's guides) than other (OSSTMM)
- OWASP (Open Web Application Security Project)
  - OWASP Web Security Testing Guide / OWASP Mobile Security Testing Guide
- NIST Special Publication 800-115 (2008)
  - Technical Guide to Information Security Testing and Assessment
- PTES (Penetration Testing Execution Standard) and PTES Technical Guidelines
- PCI Data Security Standard: Penetration Testing Guidance
- OSSTMM (Open Source Security Testing Methodology Manual)
- FedRAMP (Federal Risk and Authorization Management Program)
  - FedRAMP Penetration Test Guidance (focused on cloud providers)
- TIBER-EU
  - European framework for threat intelligence-based ethical red-teaming

Penetration test – structure

generic

- Pre-engagement
- Reconnaissance/OSINT
- Scanning/Discovery
- Gaining Access
- Maintaining access
- Reporting and Risk Analysis
- Remediation

NIST

- Planing
- Discovery
- Attack (with additional discovery)
- Reporting

PTES

- Pre-engagement Interactions
- Intelligence Gathering
- Threat Modeling
- Vulnerability Analysis
- Exploitation
- Post Exploitation
- Reporting

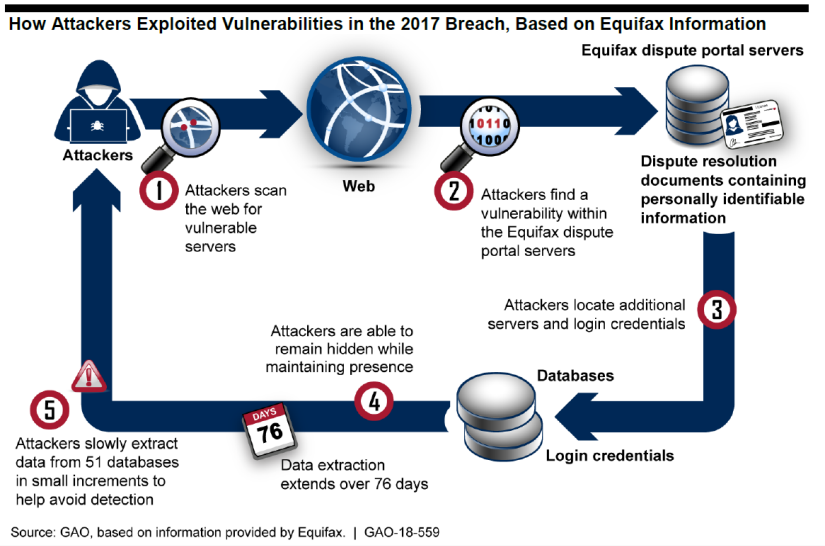
OWASP WSTG (4.2)

- Information Gathering
- Configuration and Deployment Management Testing
- Identity Management Testing
- Authentication Testing
- Authorization Testing
- Session Management Testing
- Input Validation Testing
- Error Handling
- Cryptography
- Business Logic Testing
- Client-side Testing
- API Testing

Case study 1 – Equifax (2017)

- Equifax – multinational consumer credit reporting agency
  - one of the three largest agencies of this type
  - 25 countries, 13000 employees
- vulnerability in Apache Struts Web Framework (published in March 2017)
- the attack lasted for 76 days (undetected)
- personal data of nearly 150 million people stolen
- GAO report [1] and Congressional report [2]
  - one of few detailed accounts of a high-profile breach
  - not just vulnerability and patching

Equifax – what happened



Equifax – problems that helped attackers (1)

- organizational structure: CSO reporting to CLO (Chief Legal Officer)
  - usually CSO/CISO reports to CIO or even to CEO
  - lack of coordination and cooperation
- formal patch management process in place
  - theory: critical patch applied within 48 hours
  - reality: not patched till attack discovery
  - roles in the patch management process not assigned

Equifax – problems that helped attackers (2)

- Equifax was aware of (audit 2015):
  - vulnerabilities were not remediated in a timely manner
  - inadequate asset management procedures (comprehensive IT inventory did not exist)
  - logs retained only for 14/30 days
  - no network segmentation between application servers and the rest of the network
- complex IT environment with poorly documented and operated legacy systems
- expired certificate in network traffic inspection device
  - inspection not functional
  - certificate expired 10 months before the breach
  - 300 expired certificates overall

Case study 2 – Cisco (2022)

- Cisco observed a potential compromise in May 2022 [3]
- Step 1. Attacker gained access:
  - employee personal Google account (not published how)
  - credentials stored in the browser were synchronized
  - MFA (push request): voice phishing and MFA fatigue
  - VPN access: new MFA devices (access without victim's cooperation)
- Step 2. Attacker operates inside:
  - escalation to administrative privileges
  - login to multiple systems (this alerted the Cisco Security Incident Response Team)
  - compromising Citrix servers
  - obtained privileged access to domain controllers
  - variety of tools: remote access (LogMeIn, TeamViewer), offensive tools (Cobalt Strike, PowerSploit, Mimikatz, Impacket), standard Windows tools
  - added own backdoor accounts and persistence mechanisms

Case study 2 – Cisco (2022) cont.

- Step 3.
  - attempts to exfiltrate information
  - continuous attempts to re-establish access (after eviction)
  - targeting poor password hygiene, registering domains
  - email communication to executive members
  - files posted on dark web (September 2022)
- Attacker was probably IAB (Initial Access Broker)
  - ties to threat actors UNC2447 (ransomware attacks) and Lapsus$ (data extorsion)
- TTP (Tactics, Techniques, and Procedures) consistent with pre-ransomware activity
- Cisco: a company-wide password reset, and other measures
- no other impact to any products or services, sensitive customer data or sensitive employee information, intellectual property, or supply chain operations, according to Cisco

Case study 3 – Microsoft (2023)

- Microsoft detected an attack in January 2024 [4]
- Midnight Blizzard (NOBELIUM) – a Russia-based threat actor
- initial access:
  - password spray attack (MFA was not enabled)
  - evasion techniques: limited number of accounts, low number of attempts, distributed residential proxy infrastructure
  - compromised a legacy non-production test tenant account
- inside
  - create, modify, grant access to OAuth applications
  - obtaining elevated access to the Microsoft corporate environment
  - finally, granting Office 365 Exchange Online *full_access_as_app* role
  - access to mailboxes ("*including members of our senior leadership team*")

Exercises

1. Create a free TryHackMe account (tryhackme.com)
   - verify you can connect via OpenVPN (room OpenVPN)
2. External pentest
   - https://crz.gov.sk/zmluva/8582224/ (read Appendix 2)
   - pentest specification: the good and the bad (your opinion)
3. Bug bounty programs
   - https://hackerone.com/visa?type=team
   - read policy, rules, scope, and out of scope details
   - discuss strengths and problems with this approach to security testing

Resources

1. U.S. Government Accountability Office, *Data Protection: Actions Taken by Equifax and Federal Agencies in Response to the 2017 Breach*, 2018
2. U.S. House of Representatives, Committee on Oversight and Government Reform, *The Equifax Data Breach*, 2018
3. Nick Biasini, *Cisco Talos shares insights related to recent cyber attack on Cisco*, 2022. https://blog.talosintelligence.com/recent-cyber-attack
4. Microsoft Threat Intelligence: *Midnight Blizzard: Guidance for responders on nation-state attack*, 2024. https://www.microsoft.com/en-us/security/blog/2024/01/25