Low-Code Software Security

Miguel Pupo Correia

ISCTE-IUL Low-code Software Development
Summer School '2018

U LISBOA | UNIVERSIDADE DE LISBOA

TÉCNICO LISBOA

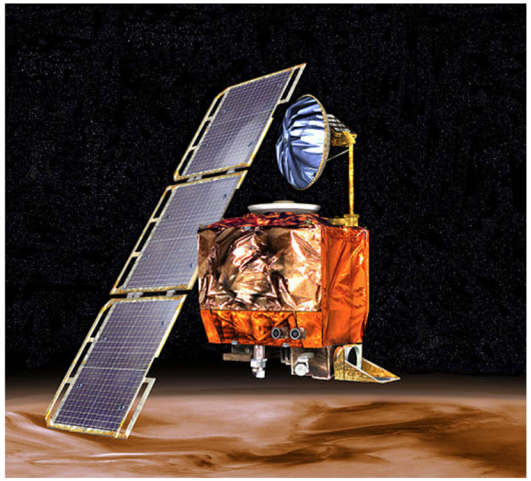
FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

inesc id lisboa 10 anos

Motivation: bad software

- NASA Mars Climate Orbiter
  - $165 million
  - Crashed due to a units conversion bug

- NASA Mars Pathfinder
  - $265 million
  - Stopped for several hours due to a priority-inversion bug

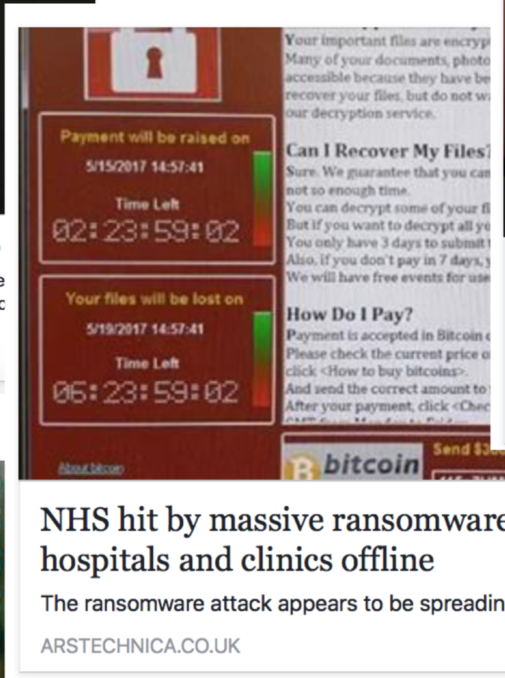


Motivation: May 12, 2017

Empresas e bancos alvos de ataque informático

Na PT, trabalhadores receberam ordem para desligar as máquinas e e ser mandados para casa. Veja a mensagem recebida pelos trabalhadc PT

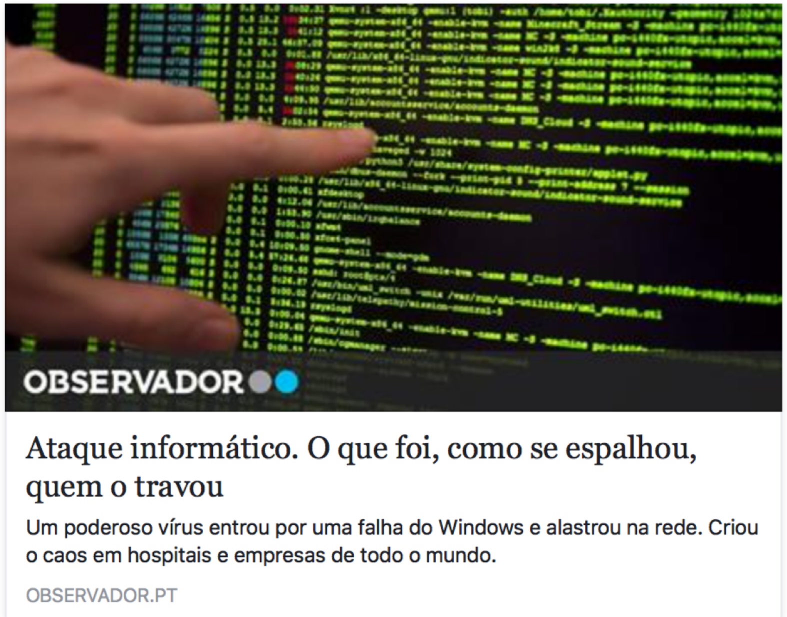
TVI24.IOL.PT



NHS hit by massive ransomware attack, many hospitals and clinics offline

The ransomware attack appears to be spreading to more NHS trusts.

ARSTECHNICA.CO.UK



Ataque informático. O que foi, como se espalhou, quem o travou

Um poderoso vírus entrou por uma falha do Windows e alastrou na rede. Criou o caos em hospitais e empresas de todo o mundo.

OBSERVADOR.PT

Portugal Telecom alvo de ataque informático internacional

A Portugal Telecom é um dos alvos do ataque informático que afetou várias empresas em Portugal, Espanha e Alemanha. A espanhola Telefónica é outr...

OBSERVADOR.PT

Ataque informático mundial: empresas portuguesas afetadas

Vírus afeta apenas os utilizadores que tenham sistema operativo da Microsoft

DN.PT | POR DIÁRIO DE NOTÍCIAS

Motivation: 2017 in numbers

- Coin mining [cryptojacking] was the biggest growth area
- Ransomware infections are up 40 percent in 2017, driven primarily by WannaCry
- 1 in 13 URLs analyzed at the gateway were found to be malicious. In 2016 this number was 1 in 20
- 62 percent increase in overall botnet activity
- zero-day vulnerabilities recorded in 2017: 4262
- new discovered mobile malware variants grew 54%
- 24,000 malicious mobile applications blocked per day

ISTR

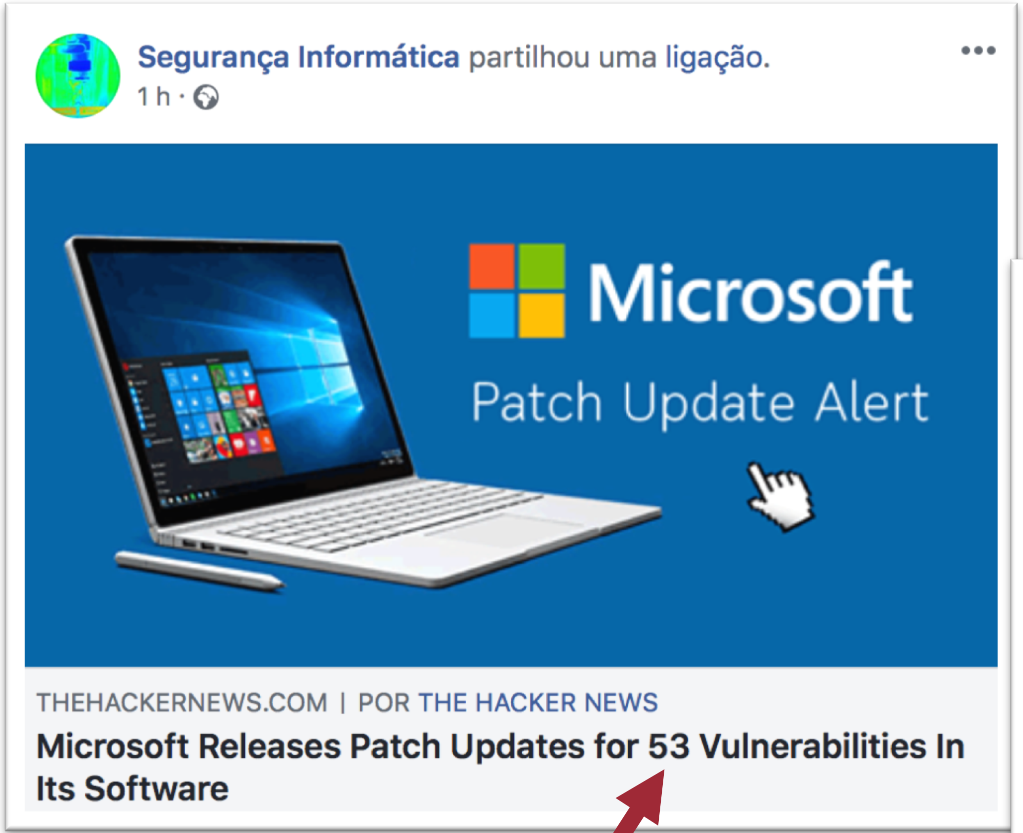
Internet Security Threat Report

Volume

23

Symantec.

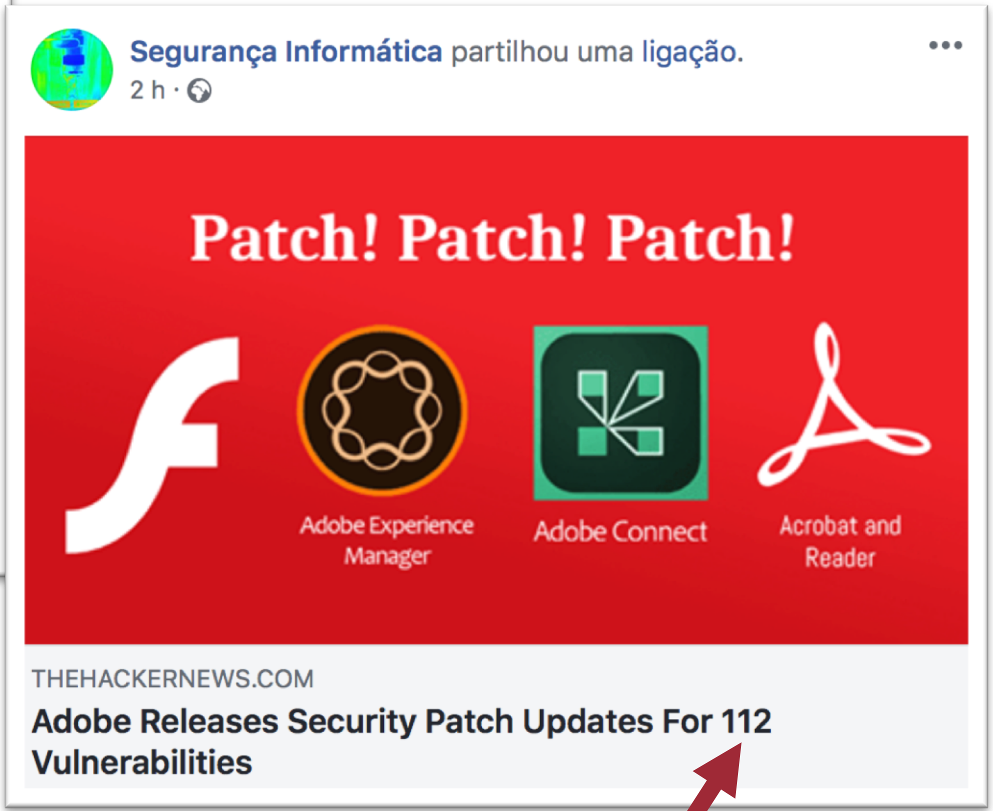
Motivation: last week (!)



Segurança Informática partilhou uma ligação.
1 h ·

THEHACKERNEWS.COM | POR THE HACKER NEWS

Microsoft Releases Patch Updates for 53 Vulnerabilities In Its Software



Segurança Informática partilhou uma ligação.
2 h ·

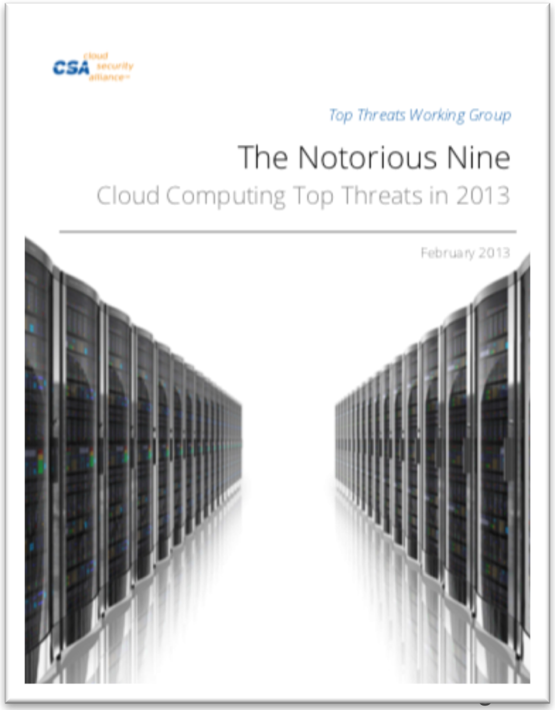
THEHACKERNEWS.COM

Adobe Releases Security Patch Updates For 112 Vulnerabilities

https://www.facebook.com/seginfportugal/

Motivation: low code vs cloud

- Low code platforms have much in common with cloud computing, so also similar security threats:
  - Data breaches
  - Data loss
  - Account hijacking
  - Insecure APIs
  - Malicious insiders
  - Shared technology issues
  - …



Top Threats Working Group

The Notorious Nine

Cloud Computing Top Threats in 2013

February 2013

Outline

Security concepts

Low-code software security problem

Users and basic protections

Web vulnerabilities and protections

Mobile vulnerabilities and protections

Low-code software development life cycle

Platform security

Wrap-up

SECURITY CONCEPTS

What is security?

- Confidentiality – absence of disclosure of data by non-authorized parties
- Integrity – absence of invalid system or data modifications by non-authorized parties
- Availability – readiness of the system to provide its service

- “non-authorized” requires a security policy, explicit or implicit

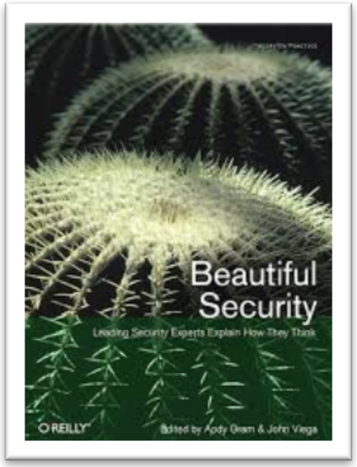
Why is security needed?

- Direct economic impact – security violation impacts business operation (loss of systems or data)
- Indirect economic impact – loss of reputation
- Human / environment impact – may kill people, cause pollution, etc.
- Compliance – legislation requires security, e.g., GDPR, NIS directive

- …life&death issues, for companies and even people

Vulnerabilities

- Vulnerability – a system (hw/sw) defect that may be exploited by an attacker to subvert security policy
- They are defects but some developers don't think so:
  - "the team leaders conveniently assumed that security vulnerabilities were not defects and could be deferred for future enhancements or projects."
- 0-day vulnerability – a vulnerability not publicly known, only privately

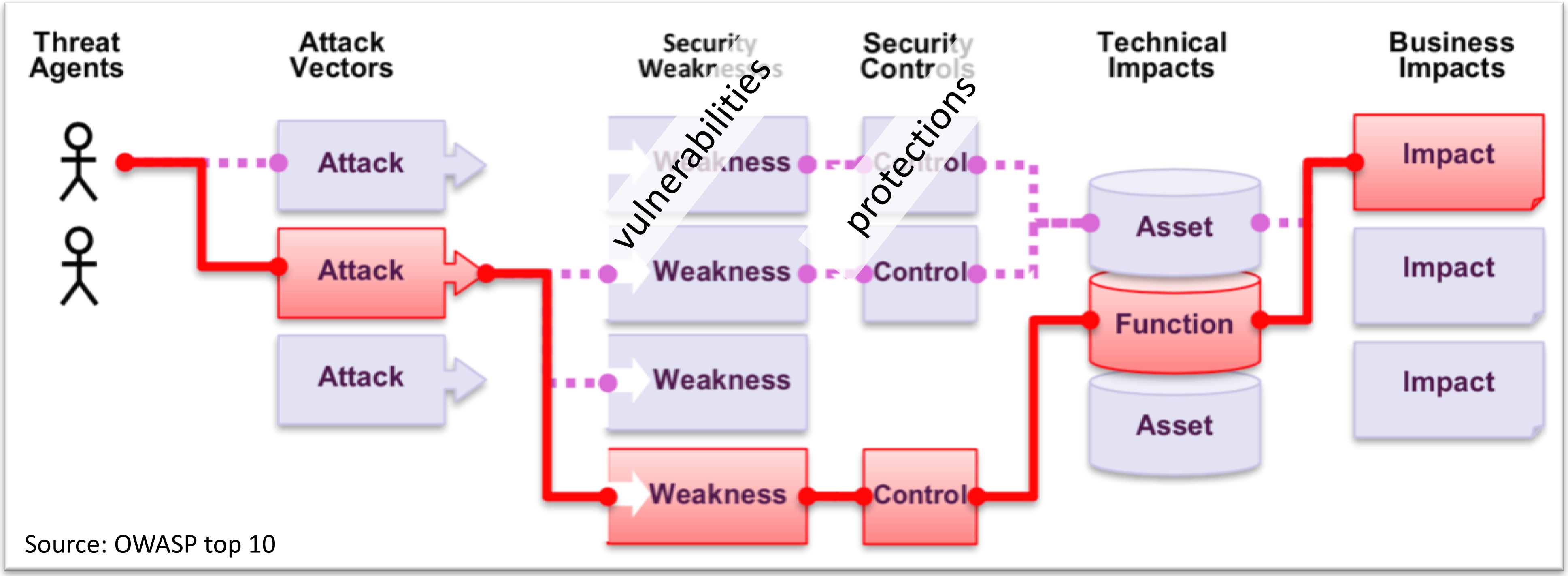

Beautiful Security
Leading Security Experts Explain How They Think
O'REILLY
Edited by Andy Oram & John Viega

Types of software vulnerabilities

- Design vulnerability
  - inserted during the software design
- Coding vulnerability
  - introduced during coding (often a bug with security implications)
- Operational vulnerability
  - caused by the software configuration or the environment in which it is executed

Attacks

- Attack – action(s) done with the intent of activating a vulnerability



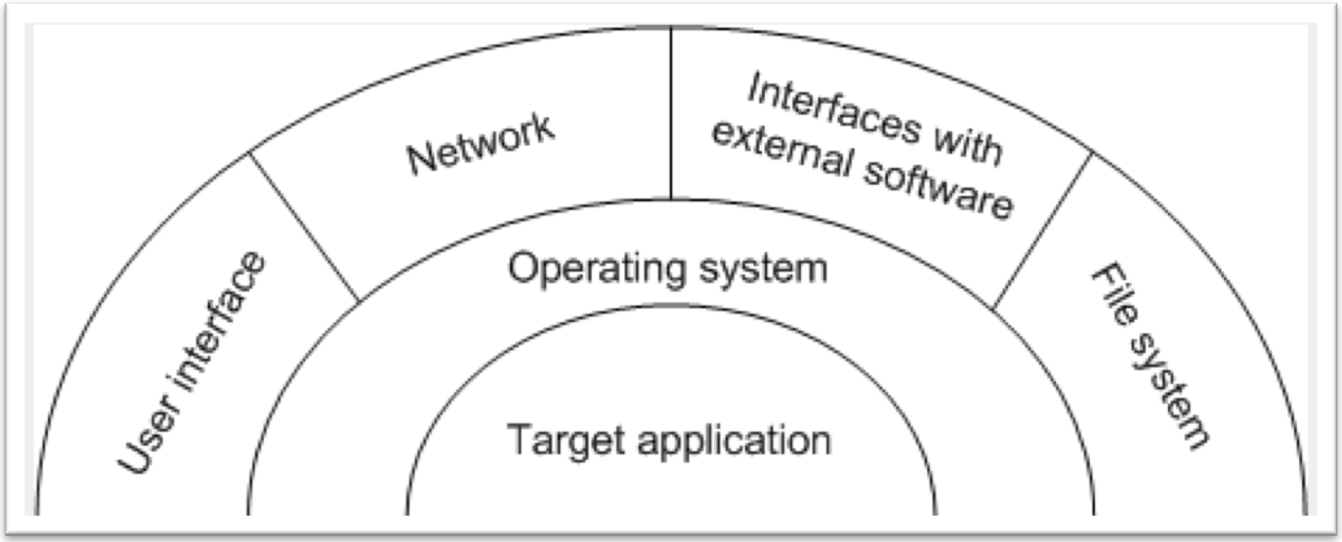
Source: OWASP top 10

Resources

- CWE – Common Weakness Enumeration
  - A taxonomy of vulnerabilities - http://cwe.mitre.org/
- CVE – Common Vulnerabilities and Exposures
  - A catalog of vulnerabilities - http://cve.mitre.org/
  - Also as NVD – National Vulnerability Database
- CAPEC – Common Attack Pattern Enumeration and Classification
  - A taxonomy of attacks - https://capec.mitre.org/

Attack surface

- Attack surface – interfaces from which attacks come
  - 1st question when speaking of an application security: what's the attack surface?
  - not trivial to understand in large software



Attacks

- Can be interactive or autonomous (with malware)
- Can be technical vs. social engineering
- Can be directed or not

Risk

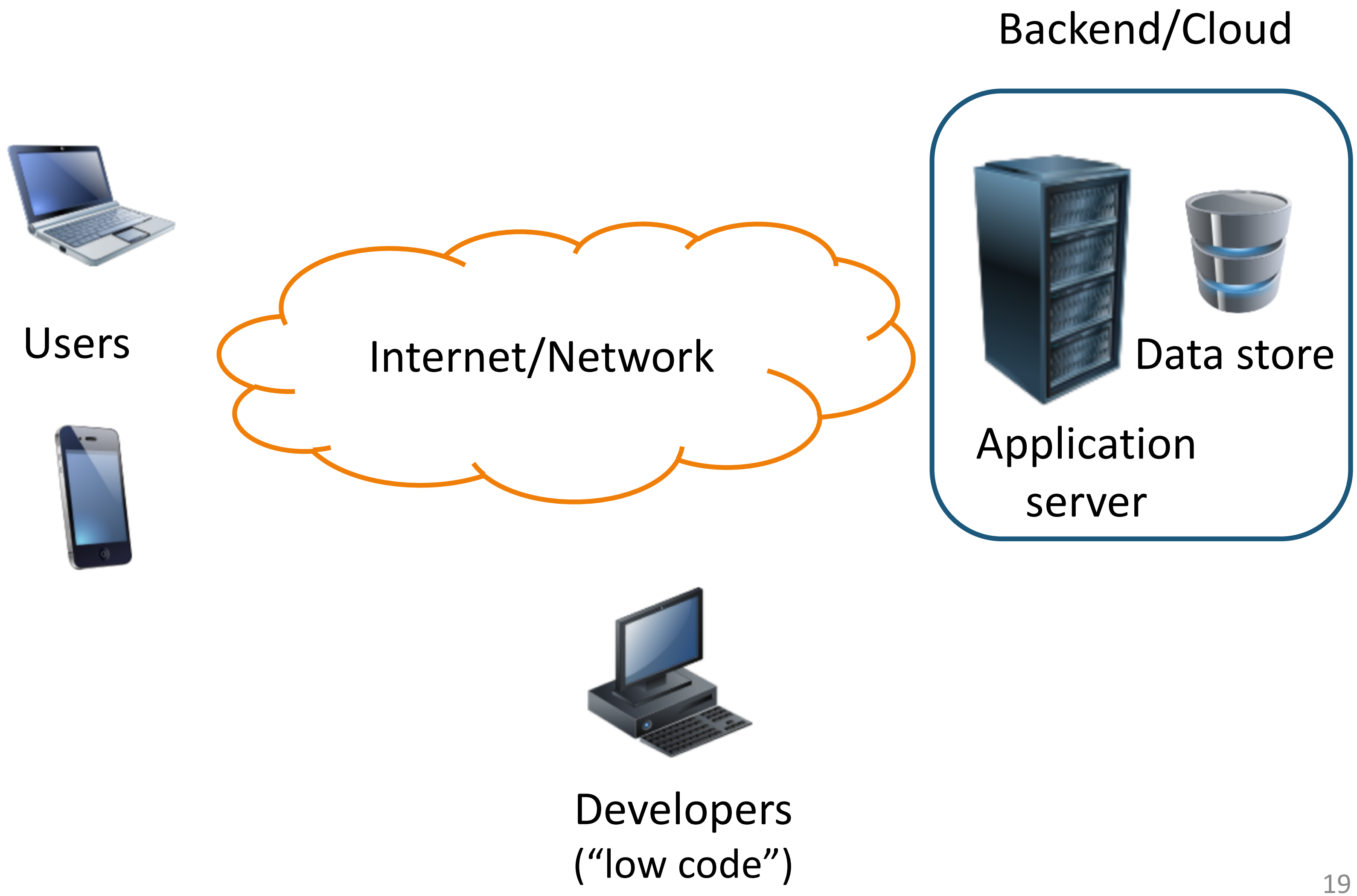
Objective is not to achieve 100% security but to have an acceptable risk (why?)

Probability of successful attack = Threat level x Vulnerability level

Risk = Probability of successful attack x Impact

LOW-CODE SOFTWARE SECURITY PROBLEM

Low-code software architecture



Backend/Cloud

Users

Internet/Network

Data store

Application server

Developers ("low code")

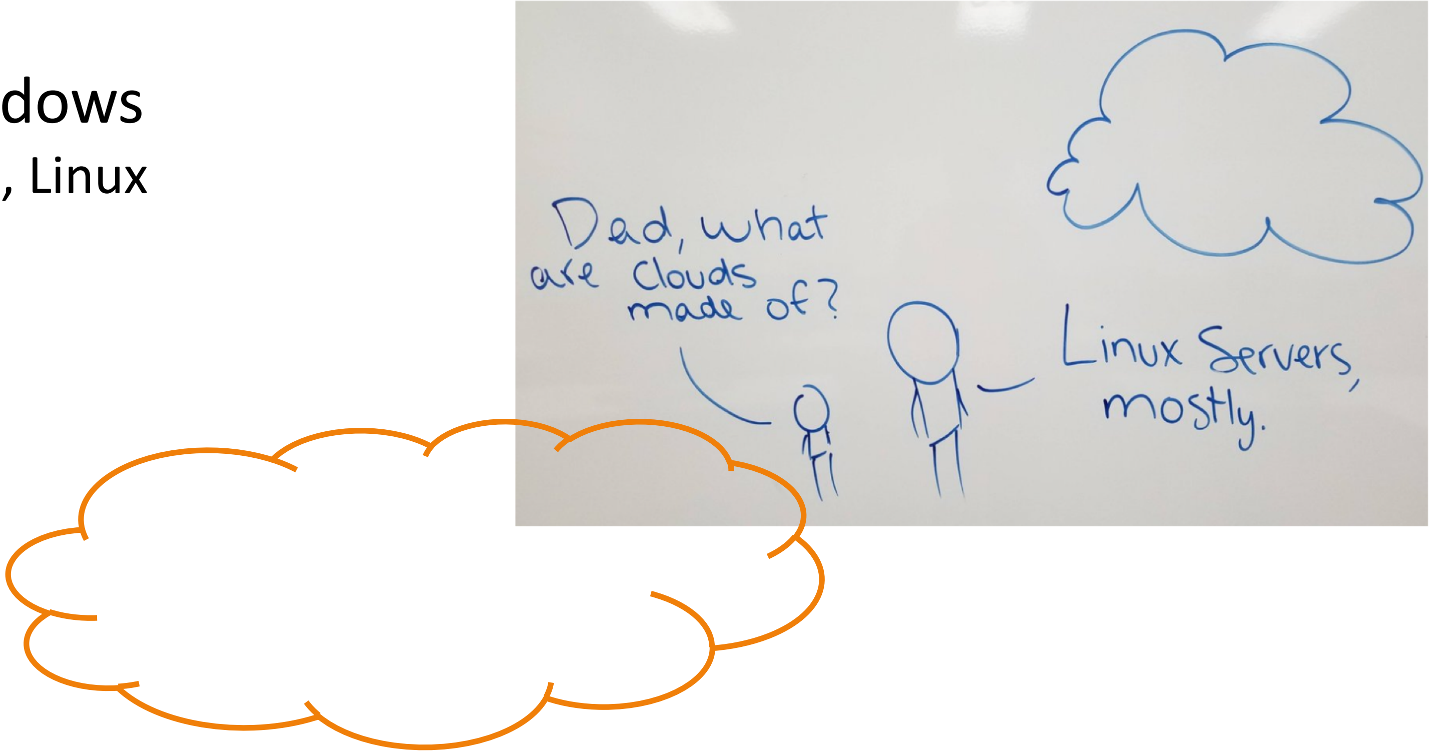
Architecture – not radically new

MS Windows

Mac OS X, Linux

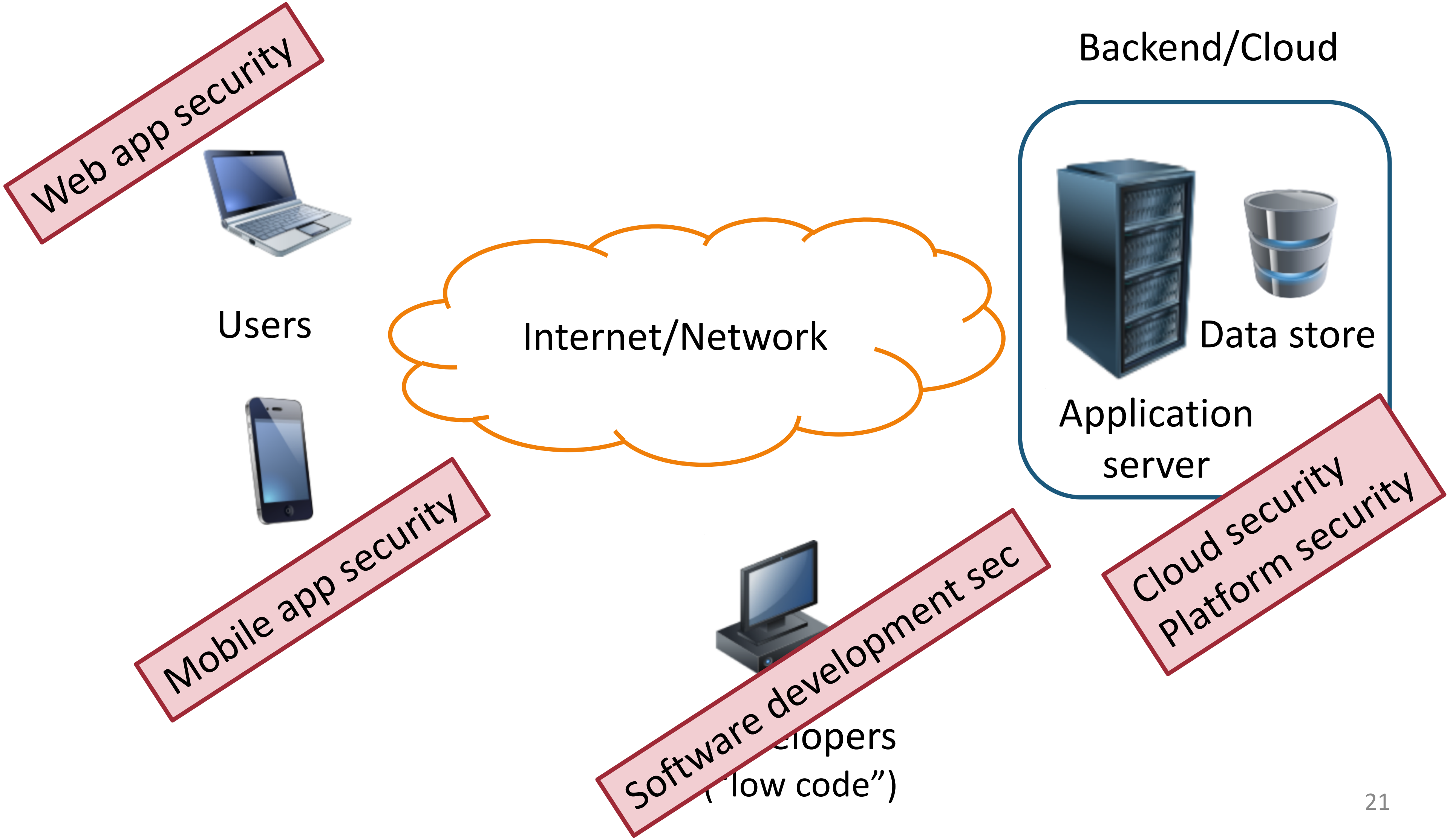
Android

iOS,…



client – server

Security – not radically new



Outline

- ~~Security concepts~~
- ~~Low-code software security problem~~
- Users and basic protections → what's already there
- Web vulnerabilities and protections → up to you
- Mobile vulnerabilities and protections → up to you
- Low-code software development life cycle → up to you
- Platform security → up to you / platform provider
- Wrap-up

USERS AND BASIC PROTECTIONS

User Authentication

- Participants = {developers, users}
- Authentication – showing to the server (in this case) that it's me who is trying to access
  - Binding of identity to a subject (a computer entity)
- Common approaches
  - username / password
  - 2-factor authentication: add SMS, smartcard, biometry,…
  - Single sign-on: same authentication for accessing several systems

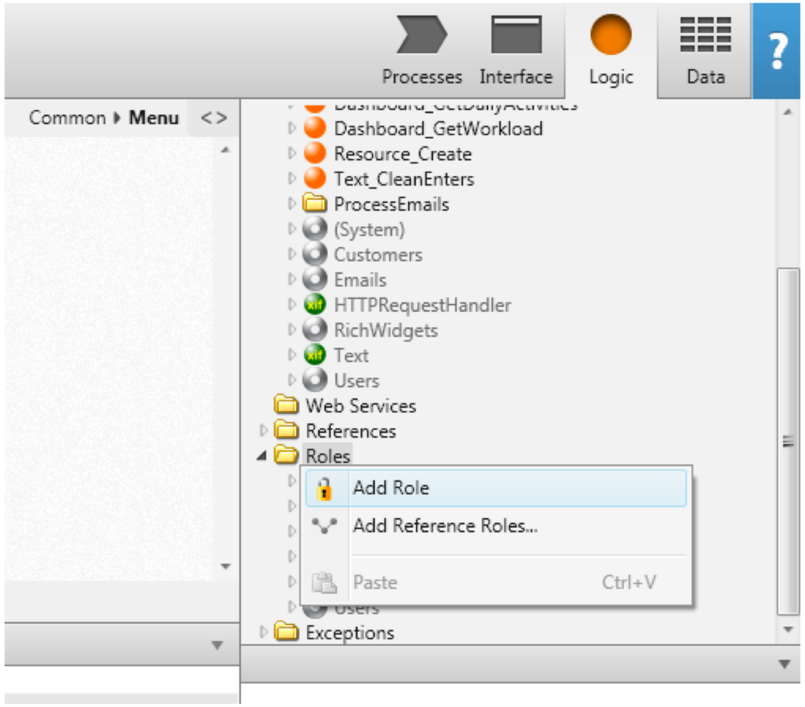
Access Control

- Access control – restrict who can do what
  - Participants have permissions; can do operations if they have the corresponding permission
  - Examples (for low code platform): permission to list applications, deploy applications, full control
- Common approaches
  - Access control lists – for each service/object there's a list of which subjects can do what
  - Role-based access control – permissions assigned to roles, roles assigned to subjects

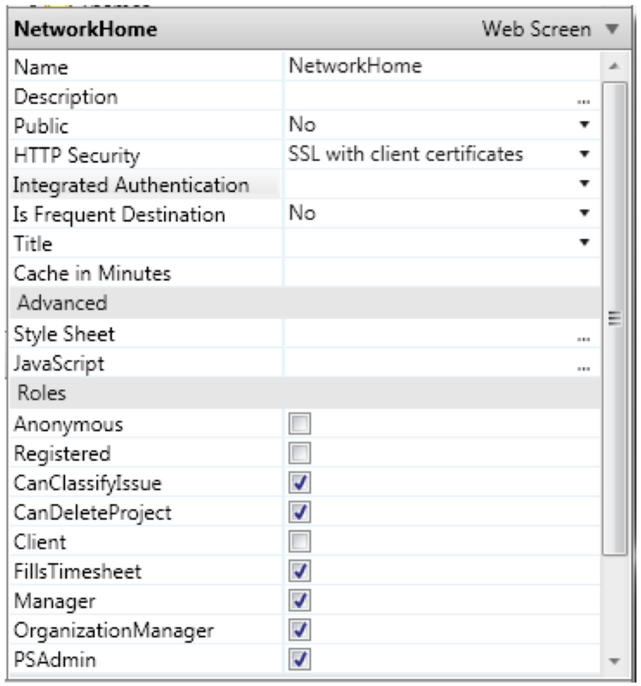
Example creating roles

outsystems

Create a role:



Assign permissions to a role:



NetworkHome Web Screen

Name	NetworkHome
Description	
Public	No
HTTP Security	SSL with client certificates
Integrated Authentication	
Is Frequent Destination	No
Title	
Cache in Minutes	
Advanced	
Style Sheet	
JavaScript	
Roles	
Anonymous	☐
Registered	☐
CanClassifyIssue	☑
CanDeleteProject	☑
Client	☐
FillsTimesheet	☑
Manager	☑
OrganizationManager	☑
PSAdmin	☑

Source: OutSystems

Communication security

- Client-server protection using HTTPS (SSL/TLS)
  - Authenticates server using public-key crypto (certificates)
  - Protects confidentiality by encrypting communication
  - Protects message integrity/authenticity by adding message authentication codes
- REST API
  - Leverages HTTPS security
  - Major issue is user authentication – schemes seen before can be used (username/password, etc.)

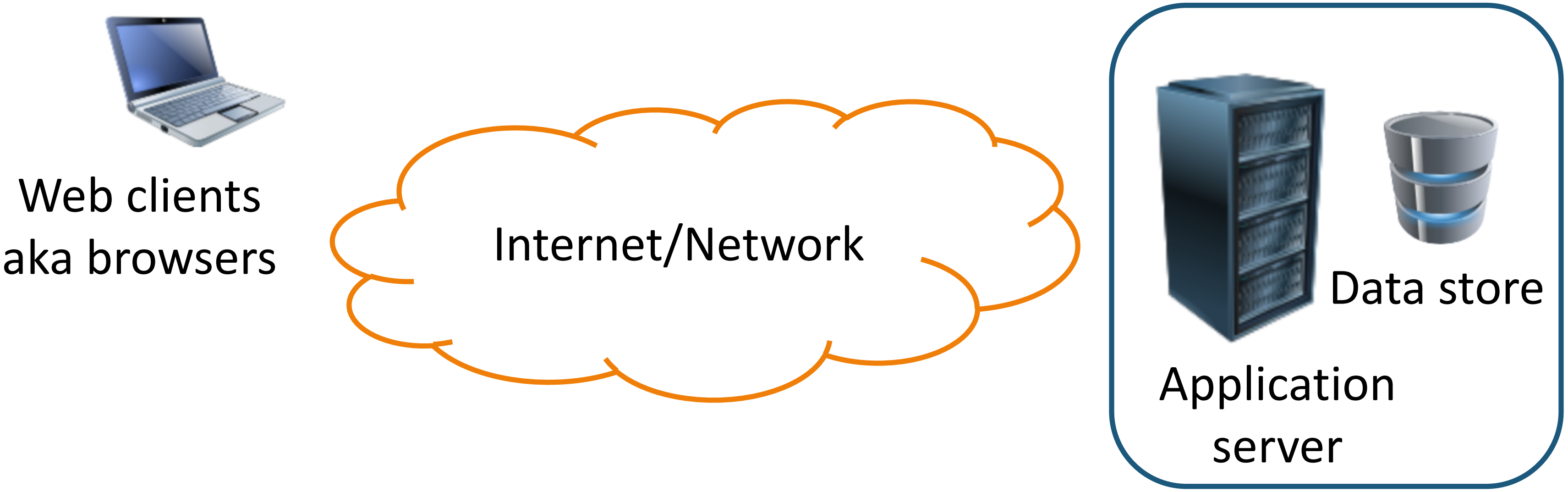
All set!

- Only authorized users
- They can only do what they are allowed to
- Communications are secured

Secure?

WEB VULNERABILITIES AND PROTECTIONS

WWW 101



- Client-server model
- Original: static HTML pages sent over HTTP; stateless
- Today: higher layer protocols (HTTPS, REST); server-side and client-side code; stateful

OWASP

The Open Web Application Security Project

OWASP Top 10 - 2013

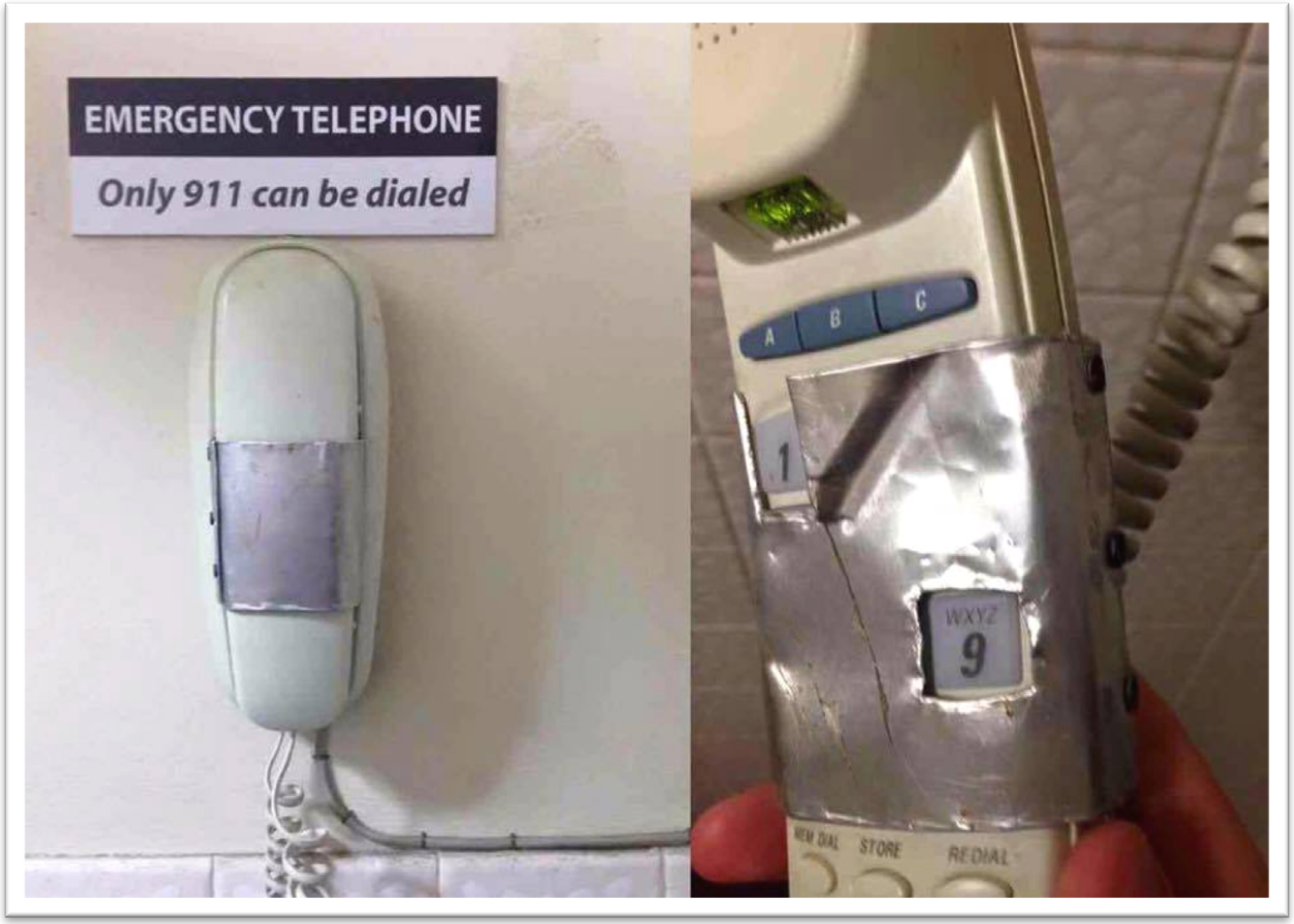
The Ten Most Critical Web Application Security Risks

release

Creative Commons (CC) Attribution Share-Alike

Free version at https://www.owasp.org

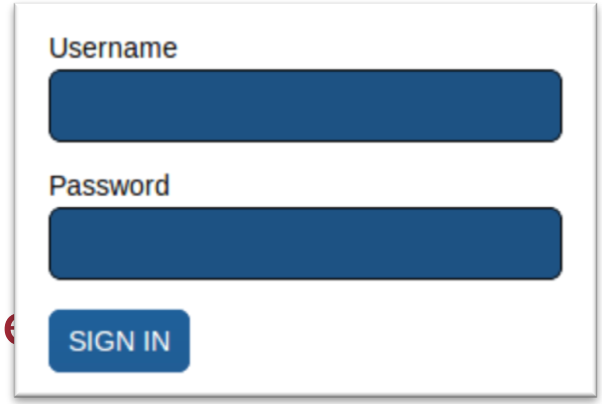
Don’t trust input!



A1: Injection

- Main case: SQL Injection
- Example (PHP/MySQL):

```
$username = $HTTP_POST_VARS[‘username
$password = $HTTP_POST_VARS[‘passwd’];
$query = “SELECT * FROM logintable WHERE user = ‘” .
  $username . “’ AND pass = ‘” . $password . “’”;
$result = mysql_query($query);
if(!$result) die_bad_login();
```



metadata

username: root
password: root’ OR pass <> ‘root

Query: SELECT * FROM logintable WHERE user = ‘root’ AND pass = ‘root’ OR pass <> ‘root’

A1: Injection

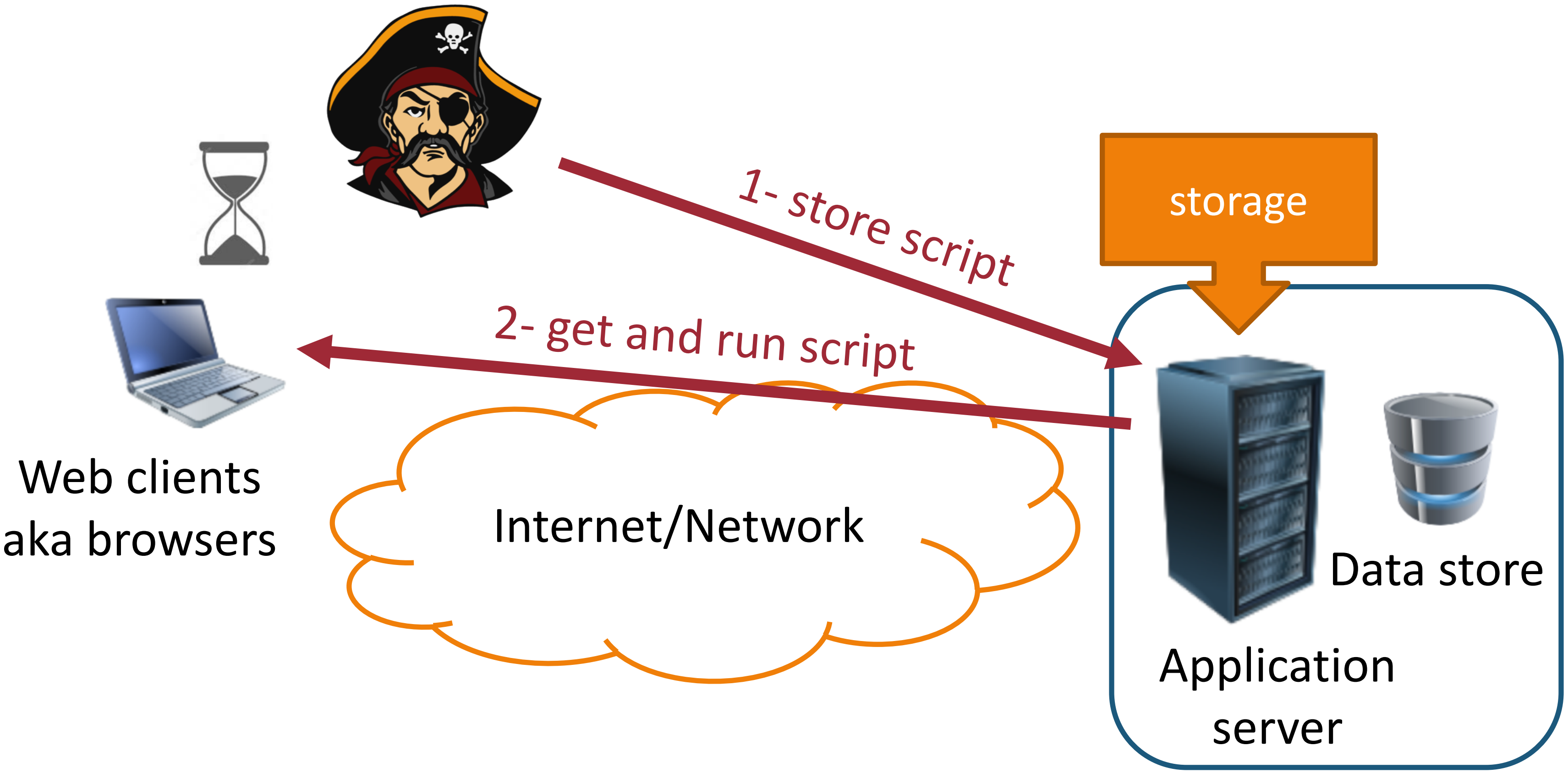
- There are several forms (SQL, XML, LDAP, XPath, XSLT, HTML, OS command injection,…)
- All have in common:
  - Attacks come from inputs (don’t trust inputs)
  - There is some server-side interpreter (e.g., DMBS, LDAP)
  - Applications accepts metadata in inputs (e.g., ’)
- Protection:
  - Use a safe API (parameterized statements) – best
  - Accept only known-good inputs (whitelisting)
  - Sanitize/encode inputs, e.g., with EncodeSQL() outsystems

A2: Broken Authentication and Session Management

- Several issues:
  - User credentials are unprotected, guessable, or modifiable
  - Session IDs are exposed / fixable
  - Authentication not invalidated with logout
- Example: session ID in the url (trivial to ride the session)
  - http://example.com/sale/saleitems;jsessionid=2P0OC2JSNDLPSKHCJUN2JV?dest=Hawaii
- Protection:
  - follow checklist of best practices

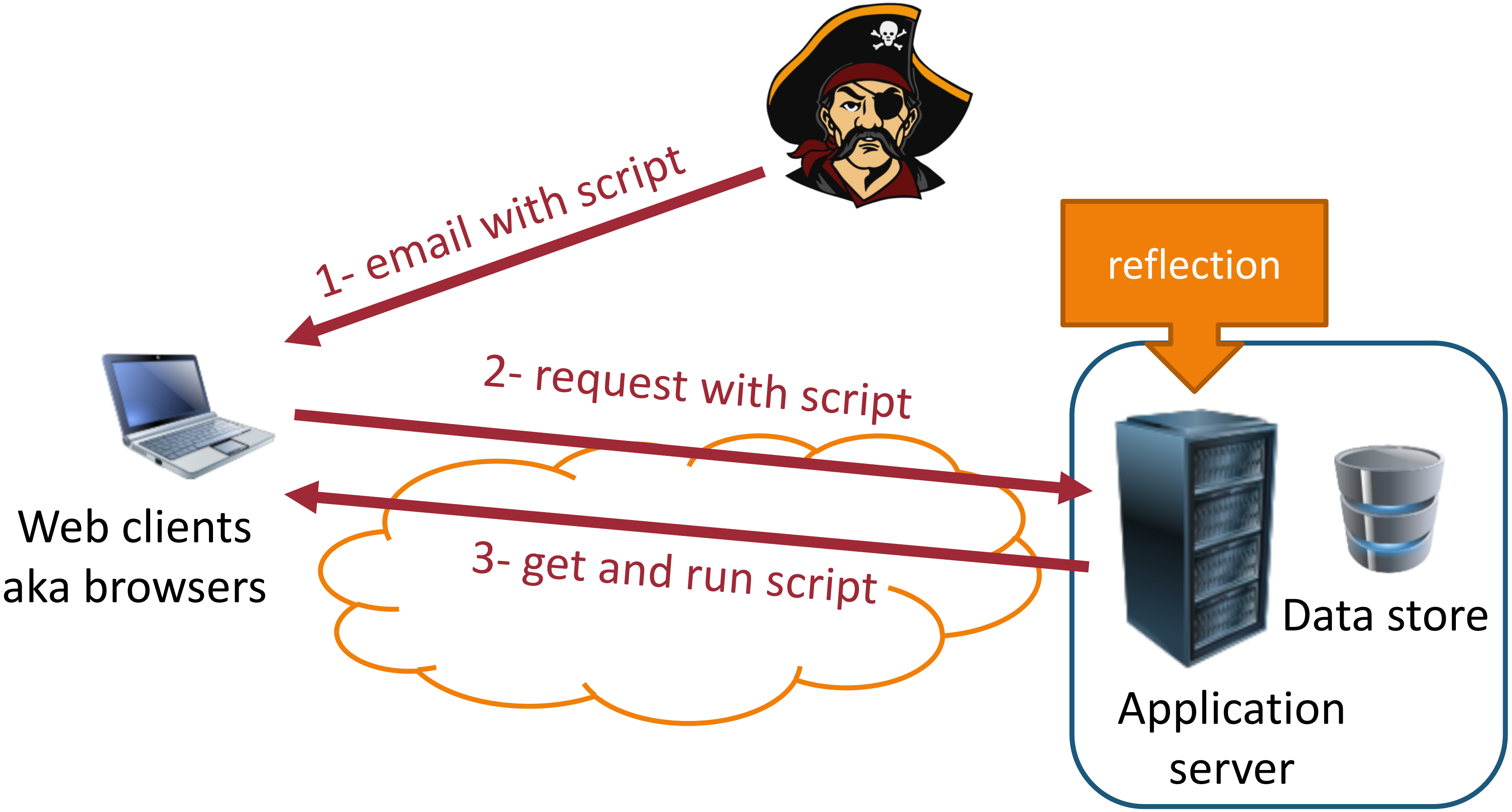
A3: Cross Site Scripting (XSS)

- Allows attacker to run script in users' browsers
- Stored XSS:



A3: Cross Site Scripting (XSS)

- Reflected XSS:



A3: Cross Site Scripting (XSS)

- Protection:
  - Input whitelisting
  - Input sanitization with reliable libraries
  - Output encoding with reliable libraries, e.g., EncodeJavascript(), EncodeHTML() outsystems

A4: Insecure Direct Object Reference

- Vulnerability: site exposes a reference to an internal object and no proper access control
  - Object ex.: file, directory, database record, key (URL, form parameter)
  - The attacker can manipulate these references to access other objects without authorization
- Ex.: direct reference to file in web page:
  - <select name="language"><option value="fr">Francais</option
  - Embeds file fr.php but attacker may send otherfile
- Protection:
  - Don't expose refs (use session info), proper access control

A5 / A9: Security Misconfiguration, Components with Known Vulnerabilities

- Several issues:
  - Vulnerable/out of date software: OS, server, DBMS, libraries
  - Unnecessary/dangerous features enabled/installed
  - Default accounts
  - Security settings not properly set
- Protections:
  - Configure properly (hardening)
  - Check for software updates automatically
  - Run vulnerability scanners

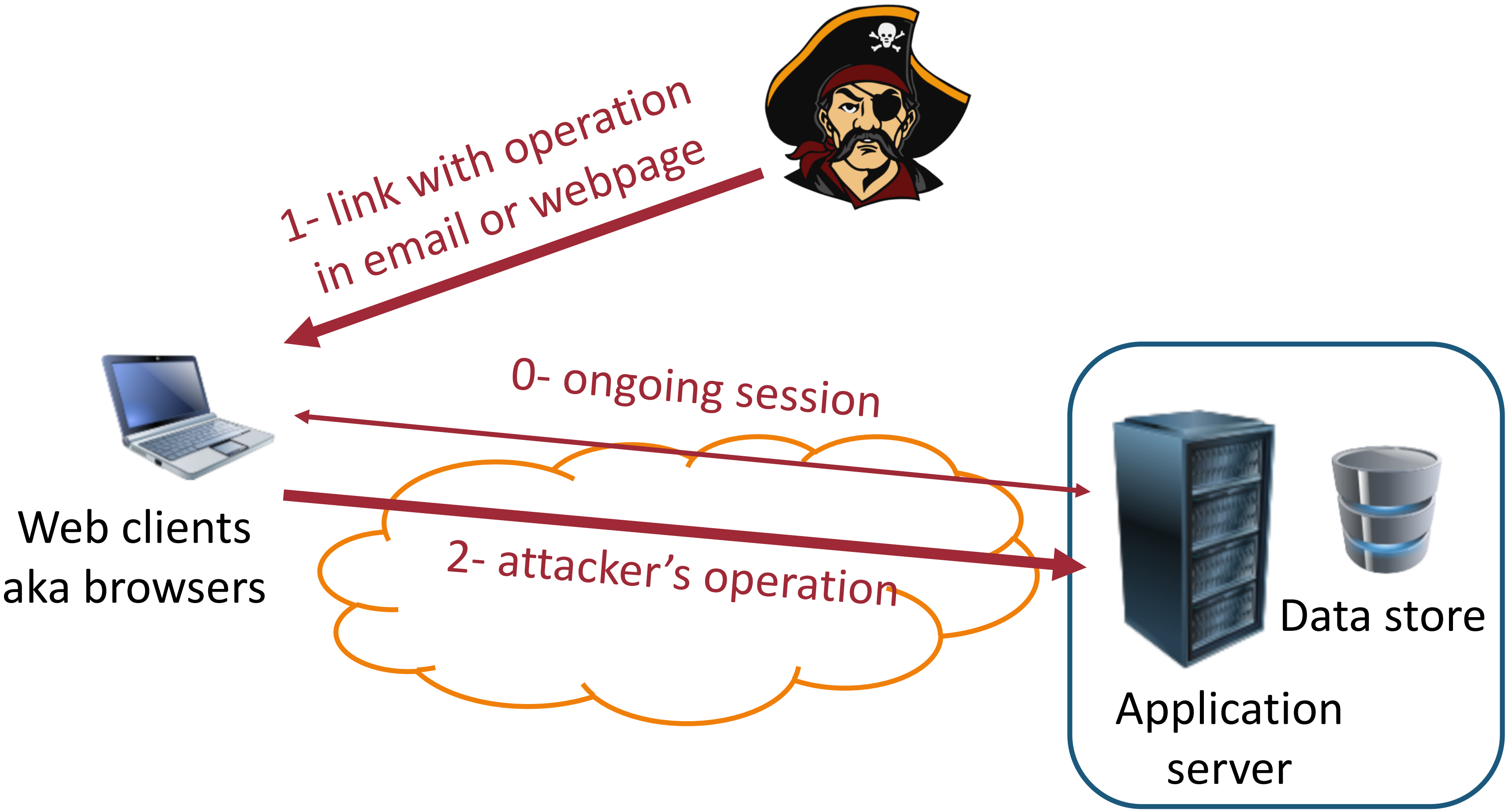
A6: Sensitive Data Exposure

- Several issues:
  - Sensitive data not encrypted, encrypted with unsafe algorithms (e.g., home-made, DES), or weak keys
  - Hard-coding keys and storing keys in unprotected stores
- Protections:
  - Use strong algorithms and keys, considering the threats
  - Store keys securely

A7: Missing Function Level Access Control

- Users access private or privileged functionality
  - e.g., pages are not protected, just inaccessible from the normal web tree (security by obscurity)
  - Attack: forced browsing
- Protection:
  - Proper access control
  - No “hidden” pages as form of protection

A8: Cross-Site Request Forgery (CSRF)



A8: Cross-Site Request Forgery (CSRF)

- Protection:
  - Insert large nonce as a hidden field in the form; do not accept operation if nonce doesn’t come outsystems
  - Critical actions: re-authenticate

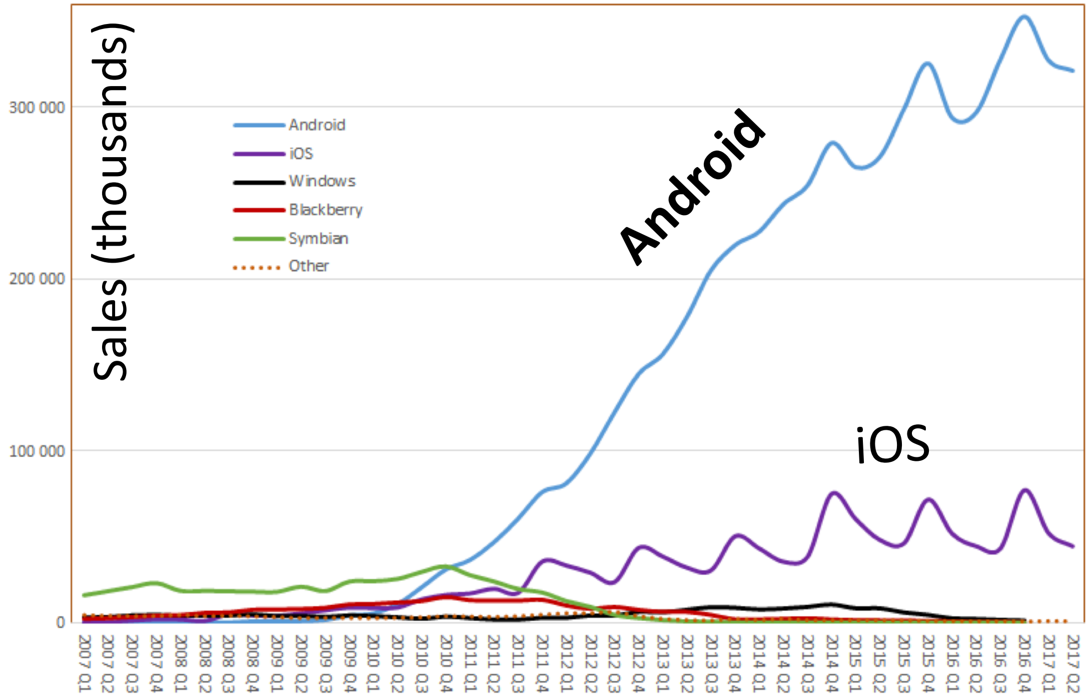
A10: Unvalidated Redirects and Forwards

- Used to trick victims into malicious websites
  - Example: site has a page called redirect.jsp which takes a single parameter named url
  - Attacker crafts a good-looking URL that redirects users: http://www.nicepage.com/redirect.jsp?url=**evil.com**
- Prevention:
  - Avoid redirects/forwards; avoid using inputs in them; validate inputs
  - Use functions that replace domain in the URL with your domain: ReplaceURLDomain() outsystems

MOBILE VULNERABILITIES AND PROTECTIONS

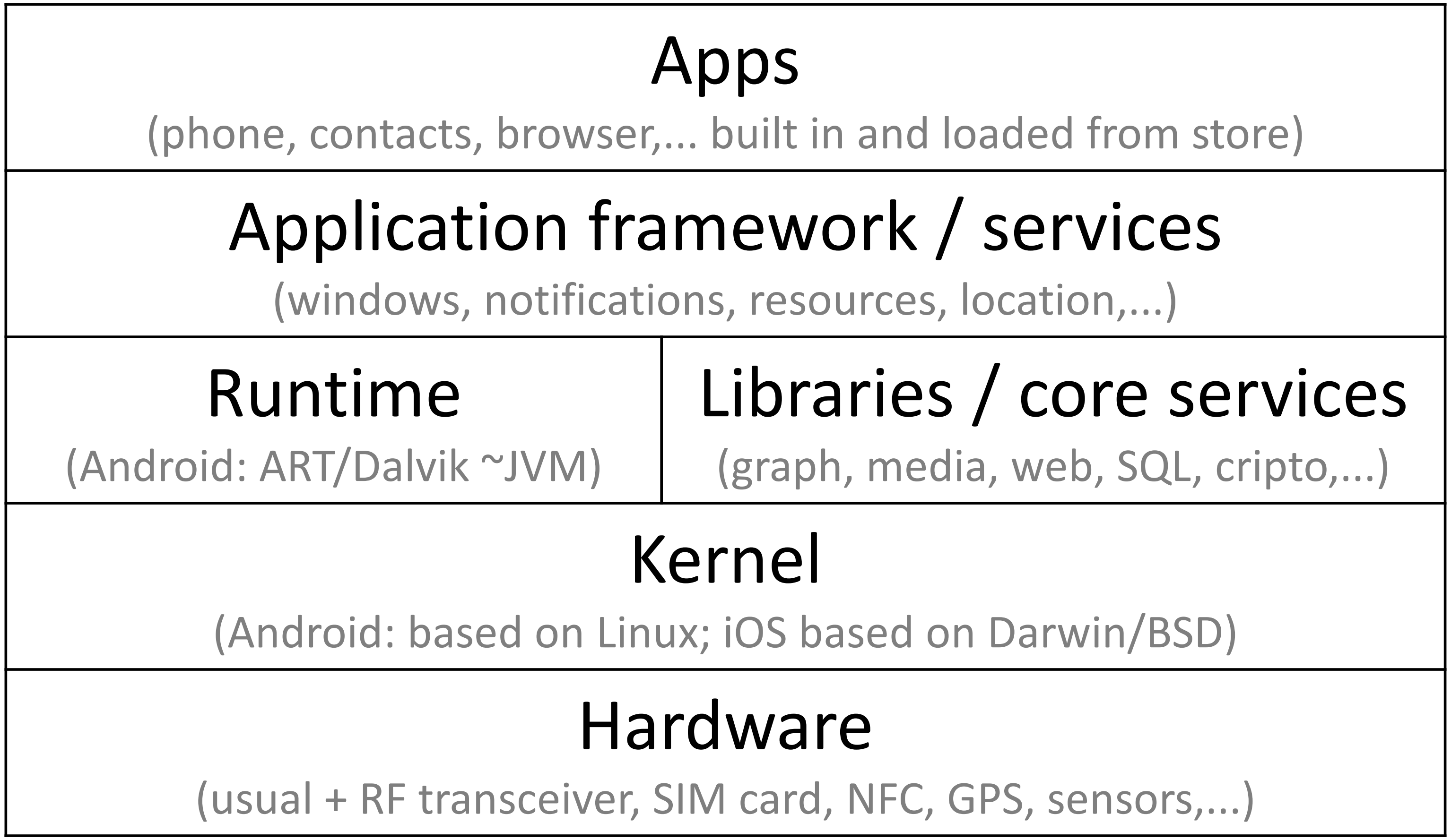
Mobile

- Devices:
  - smartphones, tablets
- Operating systems:
  - Android, iOS,...
- Applications:
  - typically webapps but client is an app, not a browser



Source: Wikipedia

Architecture



Apps

(phone, contacts, browser,... built in and loaded from store)

Application framework / services

(windows, notifications, resources, location,...)

Runtime

(Android: ART/Dalvik ~JVM)

Libraries / core services

(graph, media, web, SQL, cripto,...)

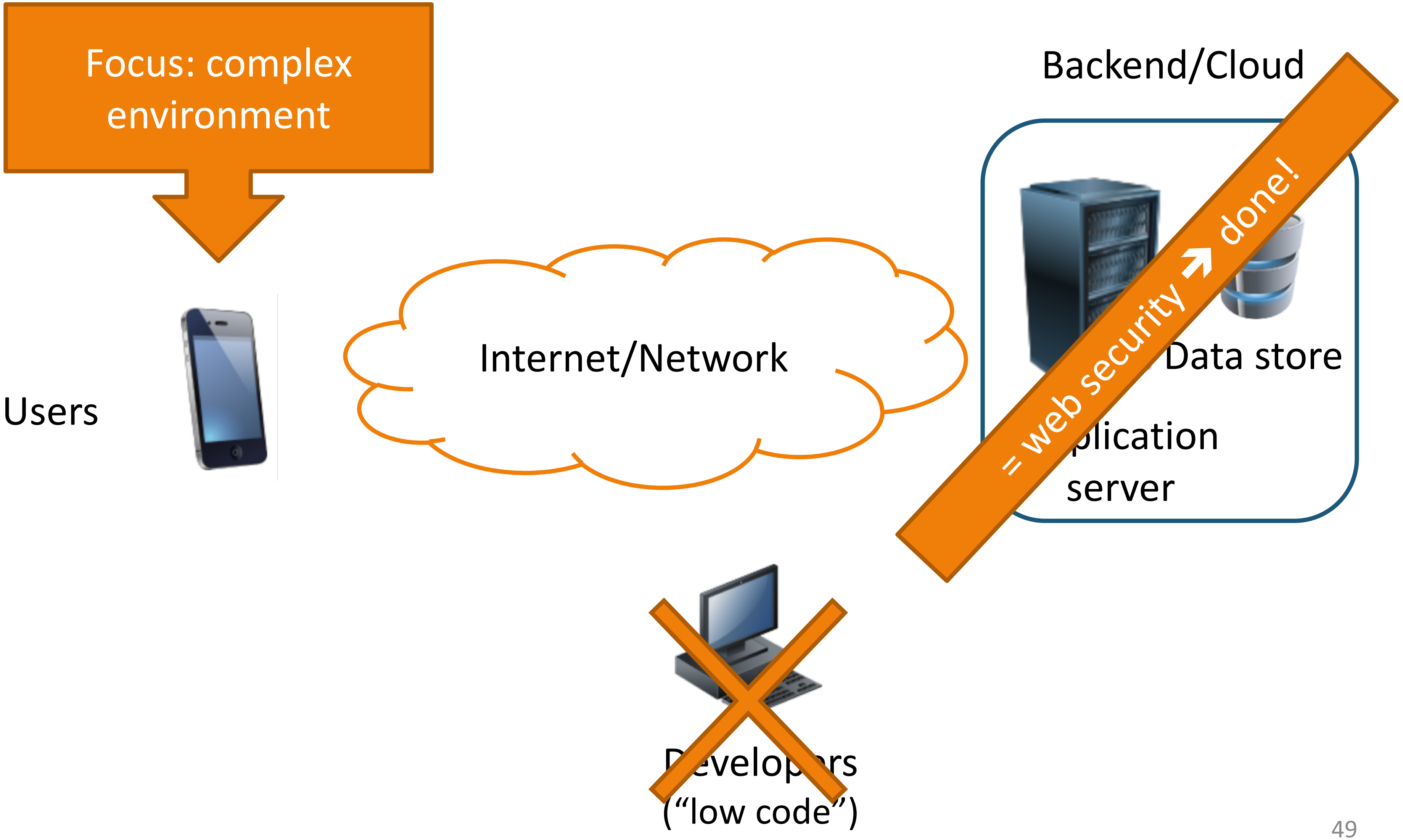
Kernel

(Android: based on Linux; iOS based on Darwin/BSD)

Hardware

(usual + RF transceiver, SIM card, NFC, GPS, sensors,...)

Low-code software security



Security problems

- Users download many apps from marketplaces, some of which are malicious
  - Google Play Store, Apple App Store, Aptoide, etc., etc.
  - Apps claim permissions, users typically grant them
  - Bad apps may do attacks by themselves (e.g., steal data) or tamper with behavior of legitimate apps
- Personal/critical data stored in devices
- Unsecure network access (e.g., open wifi)

OWASP Top Ten Mobile Risks

2014
M1: Weak Server Side Controls
M2: Insecure Data Storage
M3: Insufficient Transport Layer Protection
M4: Unintended Data Leakage
M5: Poor Authorization and Authentication
M6: Broken Cryptography
M7: Client Side Injection
M8: Security Decisions Via Untrusted Inputs
M9: Improper Session Handling
M10: Lack of Binary Protections

- There's a 2016 edition, but more a classification than a top 10
- Not showing all, but those farther away from the web top 10

M2: Insecure Data Storage

- Developers assume that users or malware can’t access stored data, so they don’t protect it
  - Storage places: SQLite databases, SD card, cloud synced, log files, property list / XML / manifest files
  - Relevant data: usernames, passwords, cookies, personal information, app data
- Protection:
  - Encrypt stored data (use proper libraries)
  - Enforce access control, e.g., not MODE_WORLD_READABLE in Android

M3: Insecure Authentication

- Weak authentication allows adversary to do arbitrary operations in the app or backend
  - Weak authentication is prevalent due to mobile devices' input form factor (promotes PINs/short passwords)
  - Users often offline, so offline authentication may be allowed and it's insecure (hard: malicious host threat)
- Protection:
  - Assume offline authentication can be bypassed, so re-authenticate with the backend when online
  - Do local integrity checks to detect unauthorized changes

M7: Client Side Injection

- Code injection in the mobile app (instead of in the backend), typically in apps using browser libraries
  - Variants of XSS and local SQL injection (in SQLite)
  - New: abusing phone dialer + SMS, abusing in-app payments
- Protection:
  - Parameterized queries; disable JavaScript; etc.

M10: Lack of Binary Protections

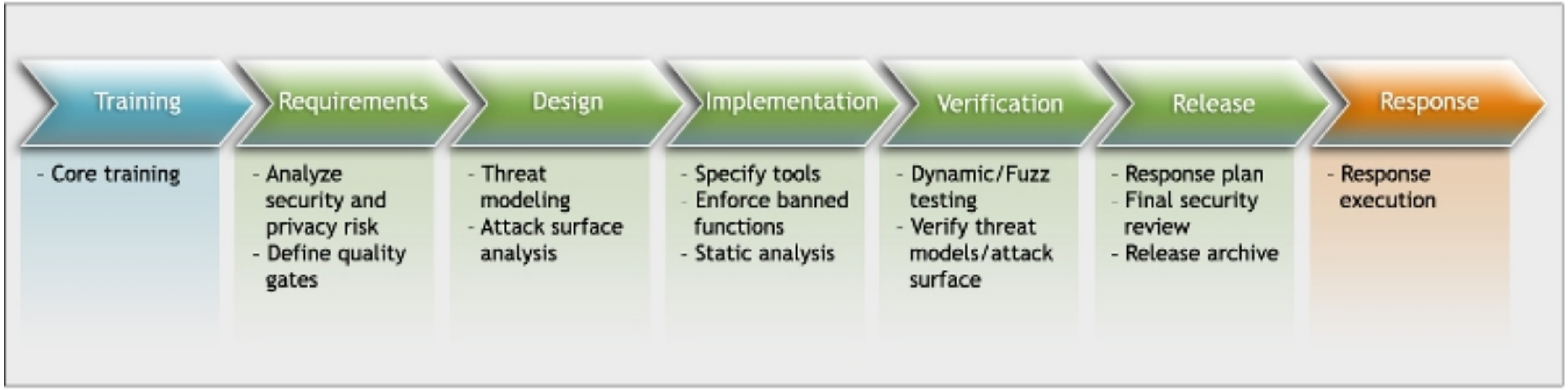
- Lack of protections against reverse engineering
  - Allow stealing confidential data, fraud, piracy, intellectual property theft
  - Several attack tools available: ClutchMod (cracker for iOS), dex2jar (Android), IDA Pro, Hopper (disassembler), gdb
  - Malicious host problem: not entirely solvable
- Protection:
  - Detect jailbreak and debuggers; use checksums; etc.

Secure?

LOW-CODE SOFTWARE DEVELOPMENT LIFE CYCLE

Security Development Lifecycle

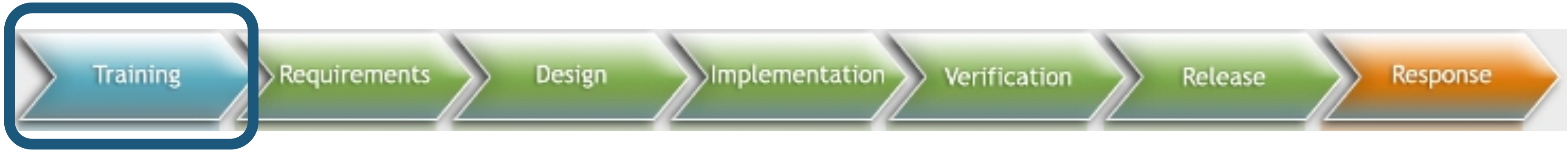
- The term is generic, but the best known SDLC is Microsoft's – for normal software development:



Training	Requirements	Design	Implementation	Verification	Release	Response
- Core training	- Analyze security and privacy risk - Define quality gates	- Threat modeling - Attack surface analysis	- Specify tools - Enforce banned functions - Static analysis	- Dynamic/Fuzz testing - Verify threat models/attack surface	- Response plan - Final security review - Release archive	- Response execution

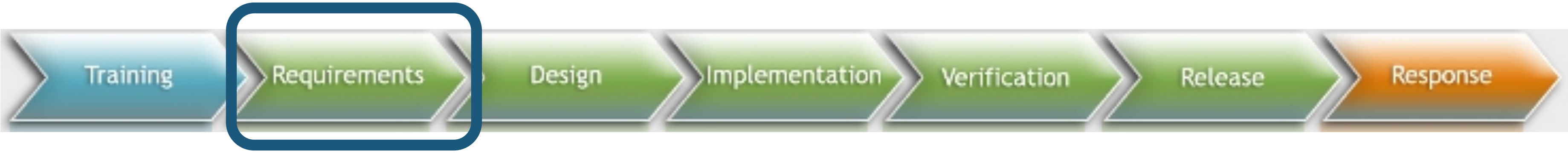
- What shall we do for low code development?

Low-Code Security Development Lifecycle



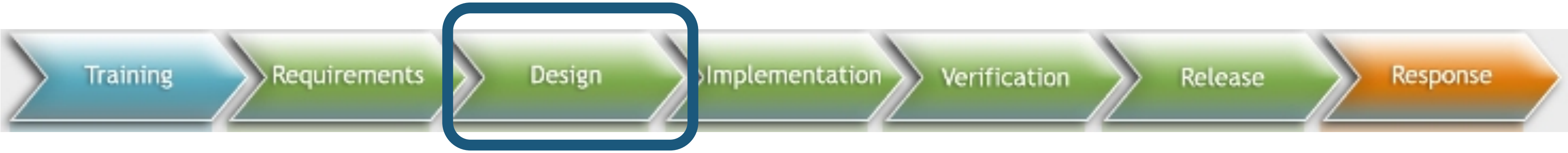
- Provide software security training for low code developers
  - “at least one security training class each year” MS SDL 5.2

Low-Code Security Development Lifecycle



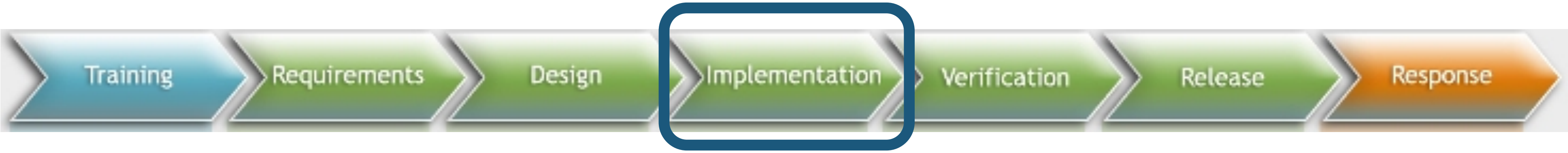
- Define the security requirements; some sources:
  - Specific project business requirements, misuse cases
  - Legislation (e.g., GDPR, NIS directive)
  - Standards (e.g., ISO/IEC 27034 Application security, IEEE 1012-2012 Software Verification and Validation)
  - Microsoft SDL 5.2 (for this and all the next ones)

Low-Code Security Development Lifecycle



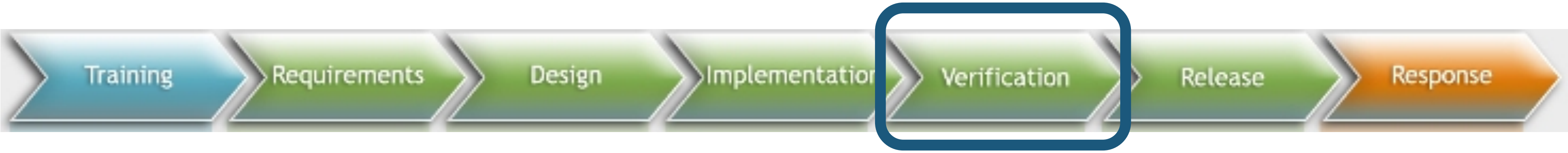
- Best practices
  - e.g., CSD "Avoiding the top 10 software security design flaws", OWASP Top 10s, low code platform vendor docs
- Threat modeling
  - Non-trivial but very useful if application is complex
- Security design principles
  - Keep design simple, least privilege, defense in depth,…

Low-Code Security Development Lifecycle



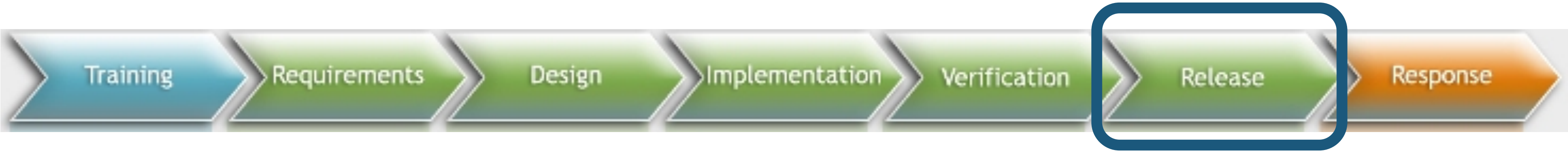
- Best practices, e.g., OWASP Top 10s, low code platform specific
- Static analysis tools – low code platform specific
  - may be integrated with IDE outsystems
- Enable dynamic low code platform specific protections if available

Low-Code Security Development Lifecycle



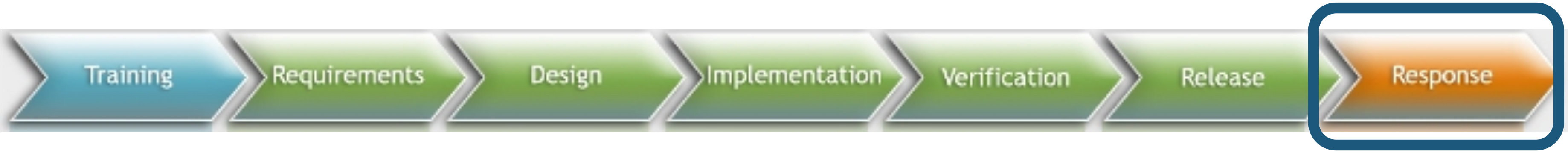
- Dynamic / fuzz testing
- Vulnerability scanners
- Tests based on the threat model (if available)
- Best practices, e.g., OWASP Testing Guide v4 or low code platform specific

Low-Code Security Development Lifecycle



- Final security review
  - e.g., peer or external code review
- Plan for when vulnerabilities are discovered (not if…)
  - patches, reports
- Plan for rollback to previous version
- Issue platform security recommendations
  - e.g., recommend Mobile Device Management (MDM)

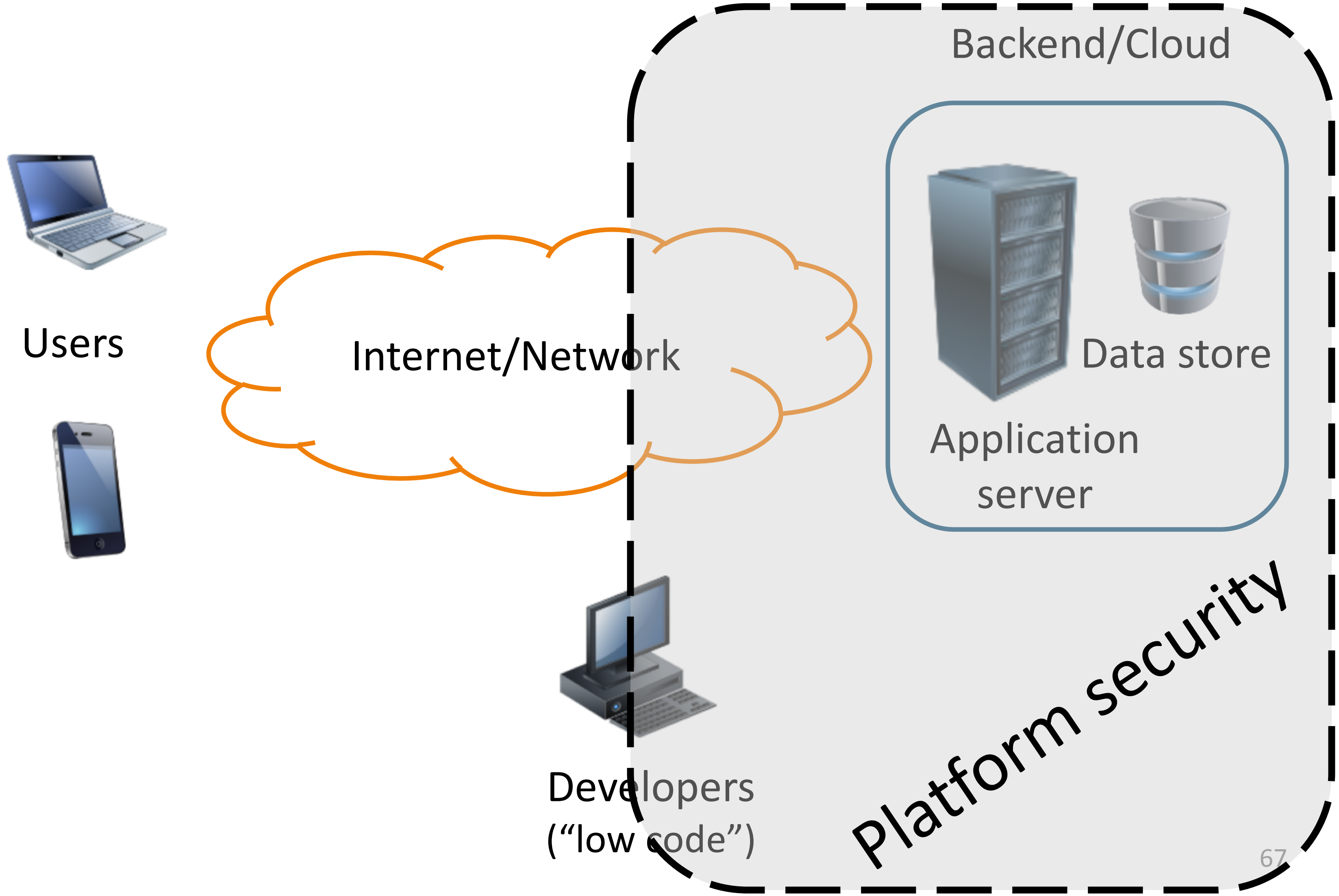
Low-Code Security Development Lifecycle



- Collect information about security events, issue reports and patches
- Possibly run a Computer Security Incident Response Team (CSIRT) 24x7

PLATFORM SECURITY

Low-code software architecture



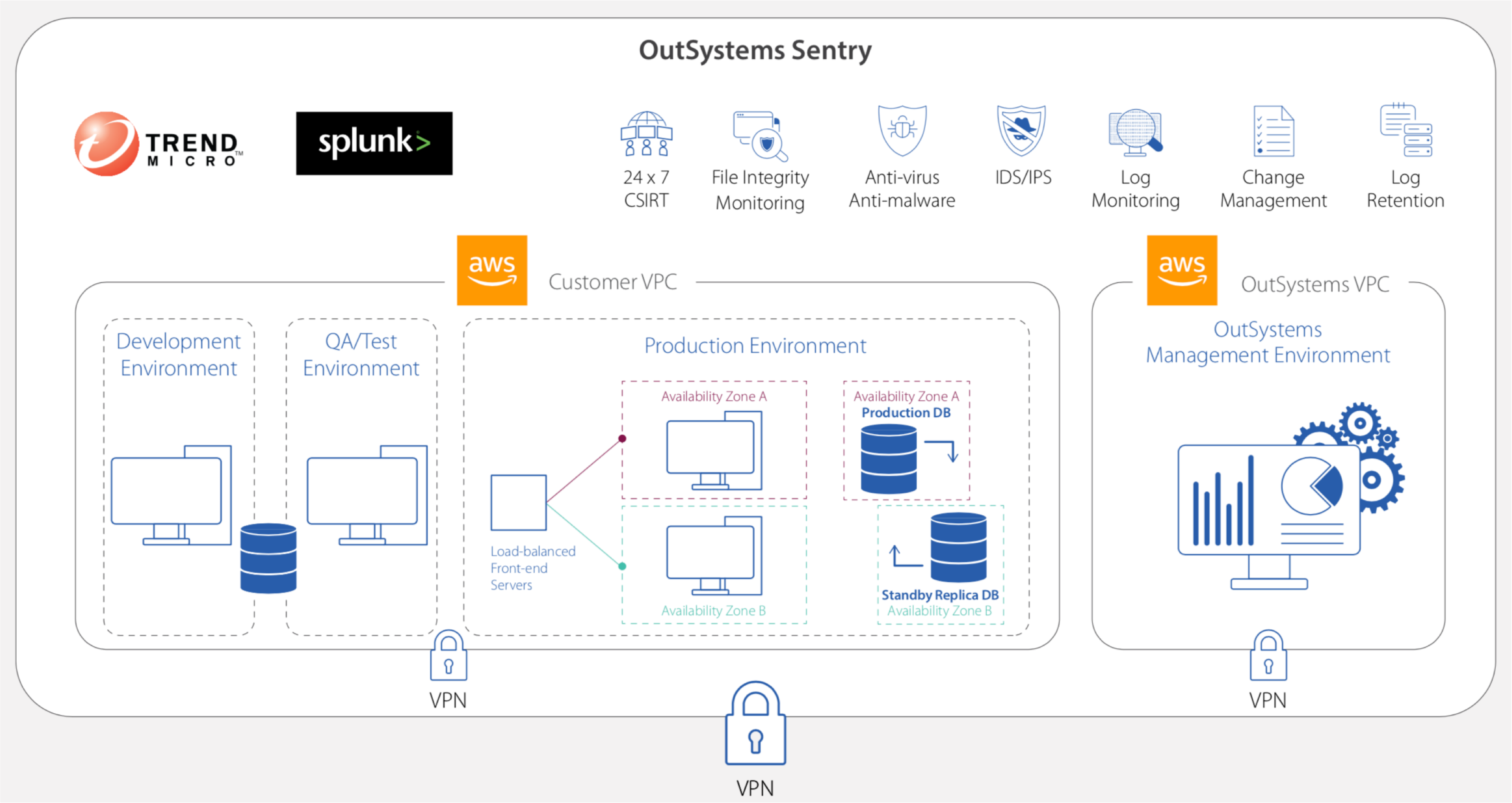
Running the platform

- on premises versus at provider/cloud
  - if at provider/cloud:

Platform protection – examples

- Virtual private networks / virtual LANs / firewalls
  - for communication security, traffic segregation, and filtering
- Anti-malware / IDS / IPS
  - for malware / attack detection and reaction
- Vulnerability management of the platform software
  - awareness of critical vulnerabilities, install updates
- Security Information and Event Management system
  - integrated security management (monitoring and control)

Platform protection – cloud example



Source: OutSystems Sentry datasheet

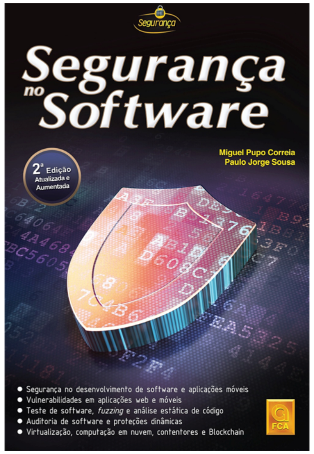
WRAP-UP

Conclusions

- Low code platform security is a new problem, but previous solutions mostly apply
  - Web security, mobile security, cloud security,…
- Focus on secure code implementation is important
- but developers must have a broad view of the secure software development life cycle
- Learn the best practices, employ the best tools

References

- Miguel P. Correia and Paulo J. Sousa, Segurança no Software, 2ª ed., FCA, 2017


Segurança
Segurança no Software
Miguel Pupo Correia
Paulo Jorge Sousa
2ª Edição Atualizada e Aumentada
Segurança no desenvolvimento de software e aplicações móveis
Vulnerabilidades em aplicações web e móveis
Teste de software, fuzzing e análise estática de código
Auditoria de software e proteções dinâmicas
Virtualização, computação em nuvem, contentores e Blockchain
FCA

- OWASP documentation cited
- Microsoft SDL documentation cited
- OutSystems online security documentation
- Salesforce Security Guide and other Force.com docs

Thank you

Miguel Pupo Correia

http://www.gsd.inesc-id.pt/~mpc/

TÉCNICO LISBOA

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

inesc id lisboa 10 anos