Protection and security of information systems

Software support security

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basic terms

ÿ Software security

ÿ Software engineering that will continue to work properly in the event

of an attack ÿ *the science and study of protecting software (including data in software) against unauthorized access, modification, analysis or exploitation*

ÿ Software security = risk management

ÿ Management = administrative policies + patch security holes + testing + auditing

ÿ Security software

ÿ Computer programs and libraries to support computer or network security

ÿ Antivirus sw, cryptographic sw, firewall, intrusion detection sw, OS security parts, …

ÿ software security ÿ security

software ÿ Software assurance

ÿ Level of confidence that the software has no vulnerabilities (whether intentional or accidental)

Application security

ÿ Application security

ÿ Measures taken during the application life cycle to prevent exceptions to the application or system security policy due to errors in the design, development, installation, upgrade or maintenance of the application.

ÿ Key terms ÿ

Property, **asset** - resource ÿ
e.g. data in a database/file or system resources

ÿ **Threat** – danger, negative effect ÿ **Vulnerability**

– a weakness that enables a threat ÿ i.e. that allows an attacker to reduce security ÿ **Attack** (attack, exploit) – an action to violate a resource ÿ

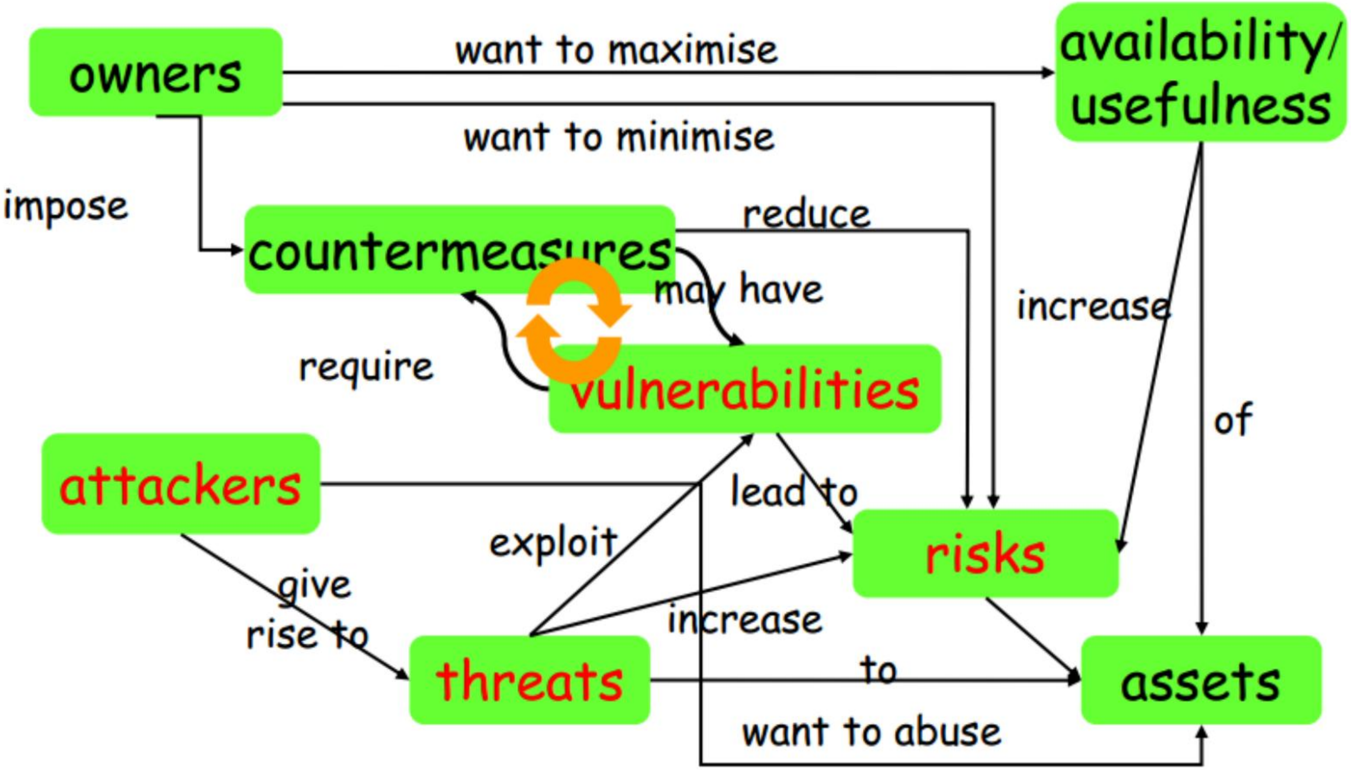
Countermeasure – a measure of protection and risk mitigation

Security concepts

ÿ Any security consideration should begin ÿ With an

inventory of stakeholders, resources and threats

… ÿ from employees, customers, … criminals



Security as a software problem

ÿ When is security a software problem ? ÿ

depends on the required changes ÿ

network problem – requires a change in network mechanisms, e.g. network

protocols ÿ OS problem – requires changing OS mechanisms, e.g. resource management p

(resource management policy)

ÿ software problem – requires a change in implementation or design (software)

ÿ Increasing insecurity ÿ By

increasing network connectivity, more and more software can be attacked! ÿ Web

applications and browsers - the weakest link and subject of attack

ÿ Reducing the difference between OS, network and applications

ÿ OS-like functionality of the Java and .NET platforms ÿ

browser as the "OS" of the future ?

Causes of software security problems

ÿ Main causes

ÿ lack of consciousness, significance

(awareness) ÿ lack of knowledge

ÿ Security as a secondary concern ÿ

primary is functionality, service, comfort ÿ

(rotten) compromise in which security loses...

ÿ **Functionality** – what the application does

ÿ **Security** – deals with what the application should not do

Security targets: CIA

ÿ Confidentiality

  ÿ denying "reading" to unauthorized users

ÿ Integrity (integrity,

  completeness) ÿ denial of changes to unauthorized users

ÿ Availability ÿ

  enabling access to authorized users, denying it to others

ÿ Non-repudiation for accountability

  ÿ authorized users cannot refuse, negate, bypass built-in procedures

Realization of goals: AAAA

ÿ Authentication **(authentication)** ÿ

verification, determination of credibility, authentication ÿ

process of identifying an individual, usually based on usernames and passwords,

based on the idea that each individual user has something that differentiates them from other users

ÿ checking whether the user is really who he is

ÿ Authorization ÿ **authorization**

check ÿ process of granting or

denying access to resources

ÿ Supervision, monitoring **(auditing)**

ÿ check if something went wrong

ÿ Action **(action)**

ÿ if it is, take measures

Where is the protection?

ÿ Protection against attacks?

ÿ *Anti-virus, intrusion detection, firewalls, etc.*

ÿ Protection against threats?

ÿ *Use forensics to find & eliminate*

ÿ *Mitigate by punishment, if possible*

ÿ Protection against vulnerabilities?

Engineer secure software!

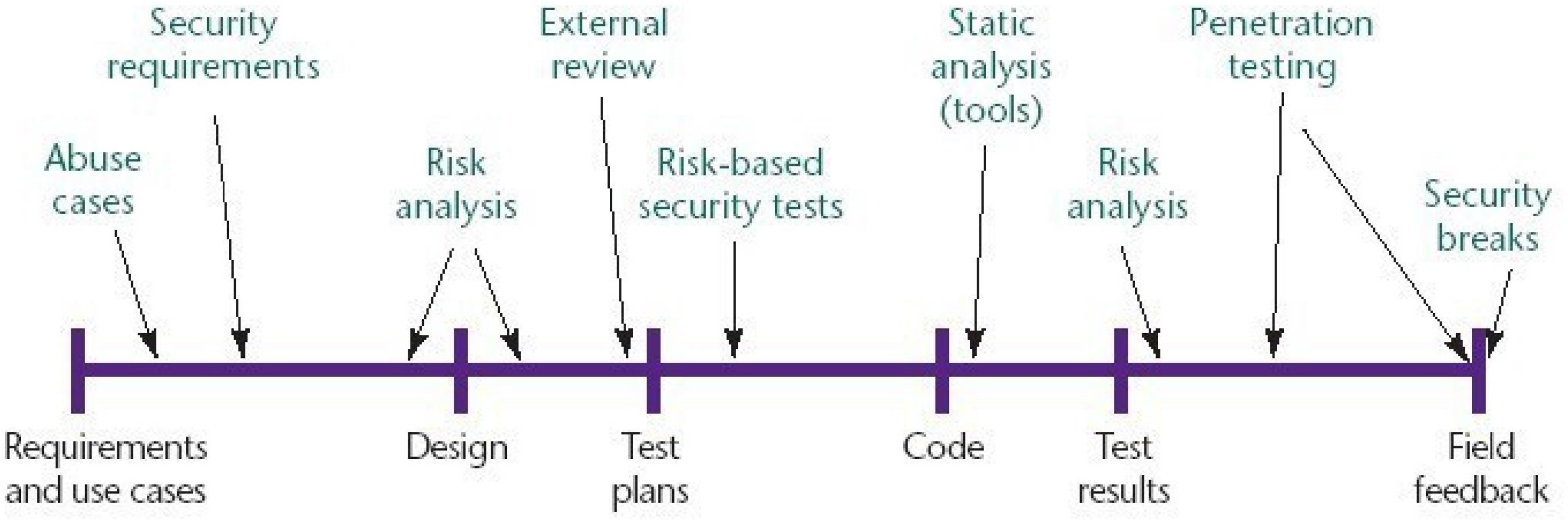
The lifecycle of secure software

Secure Software Development Life Cycle

The lifecycle of secure software

ÿ Procedures, techniques and
methodologies ÿ Safety in the
life cycle ÿ Engineering and
design principles ÿ Safety
technologies ÿ Simplified:

[Source: Gary McGraw, Software security, Security & Privacy Magazine, IEEE, Vol 2, No. 2, pp. 80-83, 2004.]



Process models of the secure software life cycle

ÿ Capability Maturity Models ÿ

CMMI for Development ÿ

Team Software Process ÿ

TSP for Secure Software Development

ÿ Correctness by Construction ÿ Common

Criteria ÿ Software Assurance Maturity

Model ÿ Building Security In – Maturity

Model ÿ Software Security Framework

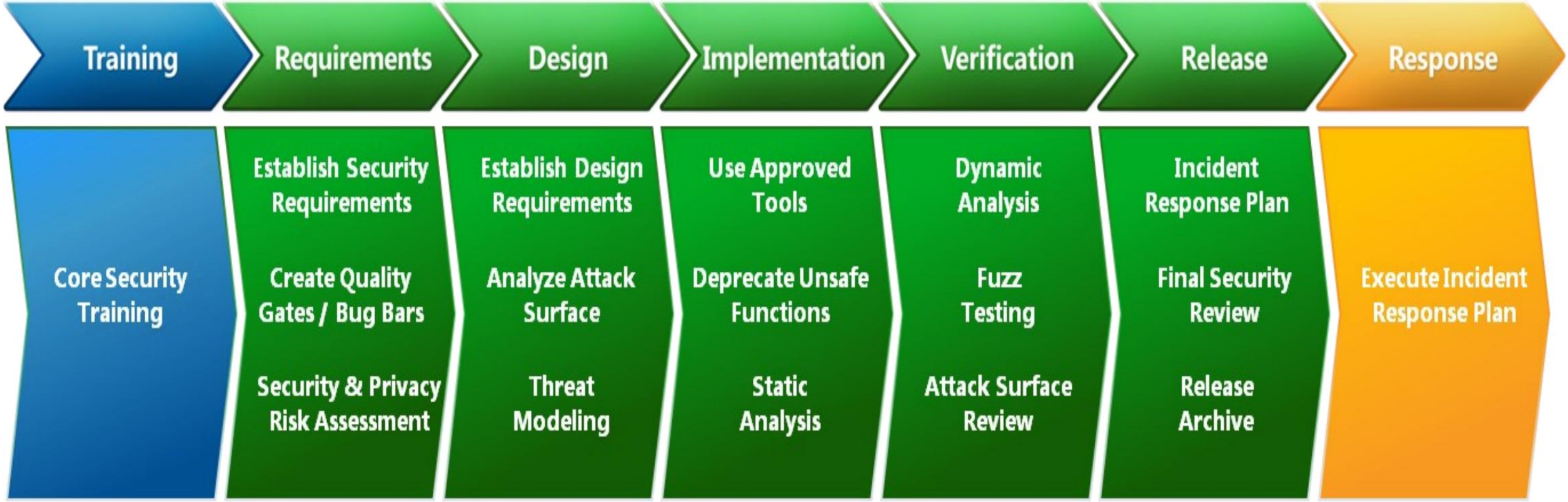
(SSF)

ÿ **Microsoft's Trustworthy Computing Security Development LC** ÿ

Security Development **Life Cycle (abbreviated SDL)** ⇨

SDL activities - practices

ÿ activities shown according to the traditional software development cycle



ÿ Analysis: security requirements, risk assessment, … ÿ Design: threat modeling, attack surface analysis, … ÿ Implementation: static analysis, … ÿ Verification: dynamic analysis, *fuzz* testing, … ÿ Delivery: incident response plan, final review

Pre-SDL Requirements: Security Training

ÿ SDL Practice 1: Training Requirements

ÿ training of all members to know the basics and stay on trend

ÿ technicians (developers, testers, ...) - at least one course per year

ÿ Basic courses, with topics (abbreviated)

ÿ Secure design

ÿ Attack surface reduction, Principle of least privilege,

Secure defaults ÿ Threat modeling

ÿ Overview, Design implications, Coding

constraints ÿ Secure coding ÿ Buffer overruns,

Cross-site scripting, SQL injection, Weak cryptography ÿ

Security testing ÿ Security and functional testing, Risk assessment,

Security testing methods ÿ Privacy (Privacy) ÿ Types of privacy-

sensitive data, design/development/testing best practices

ÿ Advanced courses - advanced design, architecture, trusted GUI, ...

Phase One: Requirements

ÿ SDL Practice 2: Security Requirements

ÿ early setting of trustworthiness requirements
ÿ during initial planning

ÿ identification of key milestones (milestones) and delivery ÿ
specification of minimum application security requirements ÿ
establishment of a monitoring system (vulnerability/work item tracking system)

ÿ SDL Practice 3: Quality Gates/Bug Bars

ÿ establishment of minimum acceptable quality levels of security and privacy

ÿ quality gate (quality gate) – for each phase ÿ e.g. remove compiler warnings
before check-in ÿ barrier for bugs (bug bar) – applies to the entire project

ÿ e.g. "no known critical/important vulnerabilities at time of delivery" ÿ team
proves compliance through Final Security Review (FSR)

Phase One: Requirements (continued)

ÿ SDL Practice 4: Security and Privacy Risk Assessment

ÿ Security risk assessments (SRAs) and privacy risk assessments

(PRAs) ÿ Assessments 1. Project parts that require threat modeling 2. Project parts that require design review 3. Project parts that require penetration testing 4. Additional testing or risk assessment requirements 5 Scope of *fuzz* testing requirements (see Practice 12)

6. Ranking of impact on privacy (Privacy Impact Rating)

ÿ Rank of impact (risk) on privacy ÿ **P1 :** high – feature/ product/service saves or transfers personal data, changes settings or install software

ÿ **P2 :** medium – privacy-related behavior is a one-time, user- initiated data transfer (eg click to go to the web)

ÿ **P3 :** low – no install, change, transfer (as previously stated)

Phase Two: Design

ÿ SDL Practice 5: Design Requirements

ÿ removal of security and privacy problems as early as
possible ÿ avoid "bolting on" of security at the end of development

ÿ distinguish between "secure features" and "security features" !

ÿ secure capabilities – general functionality to be ensured (e.g. input, robustness) ÿ
security capabilities – security-related functionality (e.g. authentication)

ÿ The design specification should

ÿ describe the software capabilities directly exposed to the
user ÿ describe how to safely incorporate functionality ÿ

be checked against a functional specification that ÿ accurately and
completely describes the use of capabilities ÿ describe how to
safely deploy (deploy) a *feature* or function

Phase Two: Design (continued)

ÿ SDL Practice 6: Attack Surface Reduction

ÿ risk reduction by reducing the space for attack ÿ by excluding or restricting access to system resources ÿ by applying the principle of least privilege ÿ by layering, where possible

ÿ SDL Practice 7: Threat Modeling

ÿ where there is a security risk ÿ consideration and documentation of the consequences in the planned operating environment ÿ consideration of the security of individual components or applications ÿ the main design activity in which they participate

ÿ program/project managers, developers, testers

Phase Three: Implementation

ÿ SDL Practice 8: Use Approved Tools ÿ

team determines tools - eg compiler/linker options, warnings

ÿ advisor approves ÿ team should stick to latest versions of

proven tools (caution!)

ÿ SDL Practice 9: Deprecate Unsafe Functions

ÿ analysis of used functions and APIs with regard to

security ÿ creation of "banned" list (banned list) ÿ marking

(eg banned.h, strsafe.h) ÿ use of appropriate checking

compiler options or special tools ÿ eg compiler options /GS (Buffer Security Check), a separate *StackGuard* tool

ÿ SDL Practice 10: Static Analysis

ÿ provides code inspection, but cannot replace it! ÿ eg

StyleCop, CodeSmart, Ndepend/ JDepend tools

Phase Four: Verification

ÿ SDL Practice 11: Dynamic Program Analysis

ÿ drive (run-time) verification that determines that the program works as designed
ÿ check for memory corruption, use of privileges, ... ÿ e.g. *AppVerifier, ANTS profiler, Rational ...*

ÿ SDL Practice 12: Fuzz Testing

ÿ a variant of dynamic analysis that ÿ tries to
cause a deadlock by entering incorrect or pseudo-random data

ÿ SDL Practice 13: Threat Model and Attack Surface Review

ÿ during development there are deviations from the
specifications ÿ review of the threat model and measurement of the
attack surface ÿ verification of changes in relation to the specifications

Phase Five: Release

ÿ SDL Practice 14: Incident Response Plan ÿ

the incident response plan defines

ÿ sustained engineering (SE) team, or emergency response plan (ERP) if there are no resources ÿ *on-call* contact with decision authority, 24x7 ÿ safety service plan for outsourced components

ÿ SDL Practice 15: Final Security Review (FSR)

ÿ thoughtful verification of all security activities, before publication

ÿ it is not "penetrate and test" or "let's incorporate the neglected and forgotten" activity!

ÿ outcomes: ÿ **passed FSR** – all problems were noticed and removed or mitigated ÿ **passed FSR with exceptions** – unresolved issues are recorded and corrected in the next announcement ÿ **FSR with escalation** – the project cannot be announced, a solution plan is made before the announcement or goes to management for further decision

Phase Five: Release (continued)

ÿ SDL Practice 16: Release/Archive

ÿ *security advisor* confirms (based on FSR and beyond) that the requirements are met

ÿ privacy impact components **P1 are separately confirmed (practice 4)** ÿ archiving

ÿ specifications, ÿ source code, ÿ compilations, ÿ threat models, ÿ documentation, ÿ response plans to incidents, ÿ licensing conditions for purchased components,

ÿ …

Optional activities

ÿ Supervision, manual code inspection (code review)

ÿ skilled individuals or security team or security consultant ÿ

focused on "critical" components ÿ most often parts that

process or store personal data ÿ also parts related to encryption

ÿ Penetration testing ÿ *white box*

analysis by simulating hacker attacks ÿ detection of potential

vulnerabilities due to coding errors, errors

configuration or other weaknesses in the application

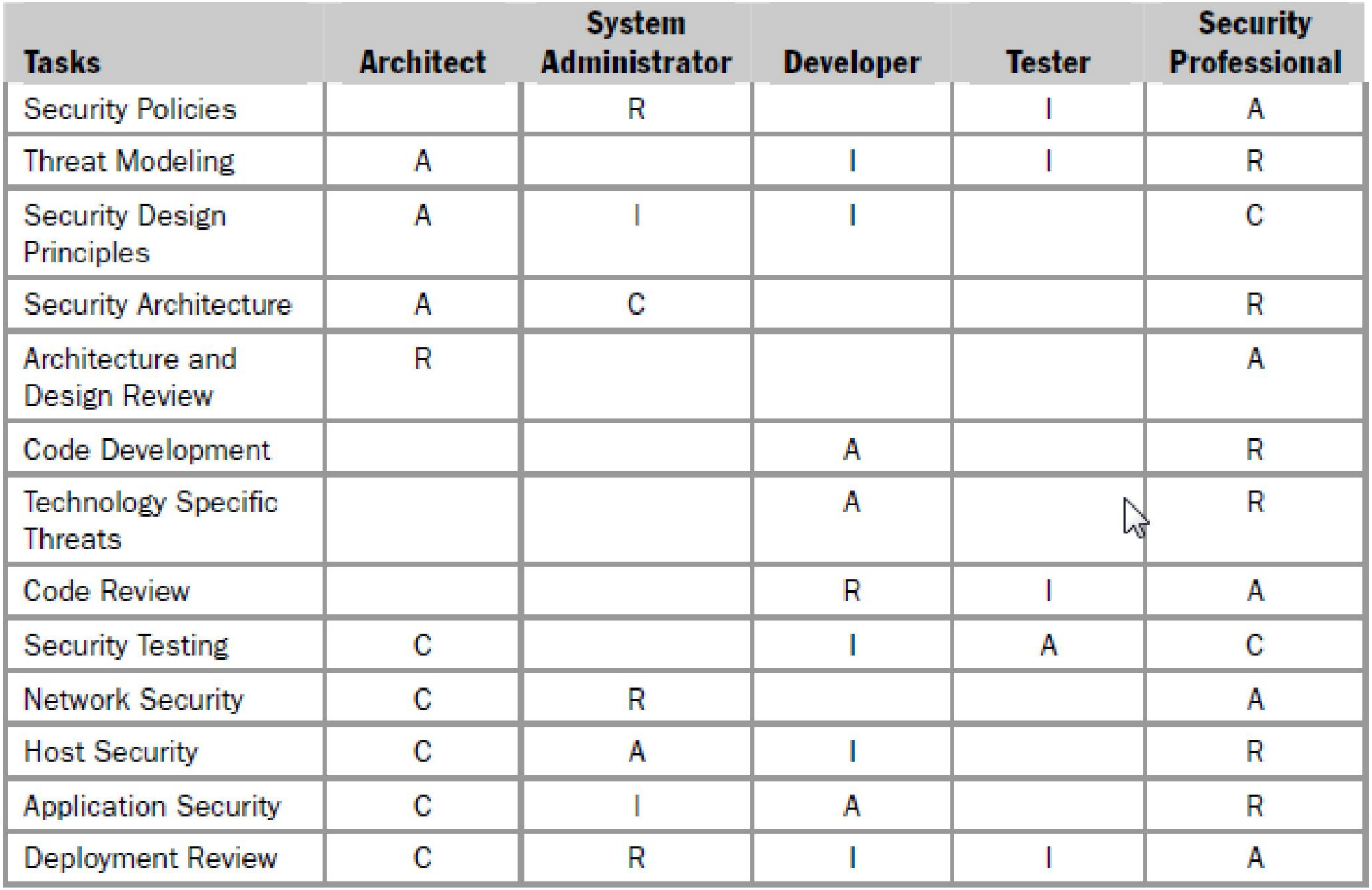
ÿ in combination with automated or manual analysis of program code

ÿ Vulnerability analysis of similar applications

ÿ by analyzing available information on the Internet

RACI Chart – roles (responsible, approver, advisor, informed)

ÿ RACI - acronym (Responsible, Accountable, Consulted, Informed)



Tasks	Architect	System Administrator	Developer	Tester	Security Professional
Security Policies		R		I	A
Threat Modeling	A		I	I	R
Security Design Principles	A	I	I		C
Security Architecture	A	C			R
Architecture and Design Review	R				A
Code Development			A		R
Technology Specific Threats			A		R
Code Review			R	I	A
Security Testing	C		I	A	C
Network Security	C	R			A
Host Security	C	A	I		R
Application Security	C	I	A		R
Deployment Review	C	R	I	I	A

Security requirements

Security Requirements

Security requirements

ÿ Requirements in general

ÿ Functional requirements - describe what the software should be

able to do ÿ Non-functional requirements - system, quality, contracts, standards, restrictions

ÿ **Security - non-functional** ÿ Estimates

of system value - system and data value ÿ Outage costs 50 kk/h, data

loss is estimated at 20 Mkn

ÿ Access control requirements – restriction on data access ÿ

Managers can …, operators can … or anon/regi/admin can

… ÿ Encryption and authentication requirements – how, where

and when ÿ Virus control requirements ÿ Some may require

functionality

ÿ Length of user input, data validation

Examples of security requirements

Scenario	
An application stores sensitive information that needs to be protected for HIPAA compliance.	Requirement Strong encryption should be used to protect sensitive data.
The application transmits sensitive user data over potentially untrusted or insecure networks.	Communication channels must include encryption to prevent snooping and cryptographic authentication to prevent *man-in-the-middle* attacks.
The application supports multiple users with different privilege levels.	Action authorizations at each privilege level should be defined. Test different levels.
The application uses SQL for data entry. The	Define SQL injection prevention Control buffer
application is written in C/C++	sizes, prevent write format modification and integer overflow.
The data is displayed in HTML	Prevent XSS attacks
The application requires change tracking	Define tracking functions. Provide a change log.
The application uses cryptography.	A secure pseudo-random number generator should be used

Request sources

ÿ Users

ÿ Security implication of functionality

ÿ Protection against SQL injection for applications over BP

ÿ Protection against XSS injection for web applications

ÿ Regulatory compliance ÿ

Information Security Act ÿ Personal

Data Protection Act ÿ Federal Information

Security Management Act (FISMA) – US government resources ÿ Sarbanes-Oxley

(Sarbox or SOX) – US public companies ÿ Health Insurance Portability & Accountability

Act (HIPAA) – medical data

Requirements engineering procedures

ÿ SQUARE ÿ

Security QUAlity Requirements Engineering Methodology from CMU/SEI

ÿ TRIAD

ÿ Trustworth Refinement through Intrusion-Aware Design from CMU/SEI

ÿ ...

ÿ SecureUML (UML, OCL), UMLintr, UMLsec

ÿ ...

ÿ Security Use Cases, Misuse Cases, Abuse Cases (MUCs)

ÿ Cases of use, abuse (unintentional) or abuse (intentional) ÿ scenarios where a participant compromises the system

A systematic review of security requirements engineering, Mellado et.a., 2010

Cases of abuse

ÿ View of the adversary/attacker

  ÿ Access to user data ÿ

  Change of price, rating, …

  ÿ Denial of service

ÿ Case development

  ÿ Brainstorming – assumptions, attack patterns, risks

ÿ Security requirements – generalized form of MUCs

  ÿ Anti-requests – what NOT to disable

An example of the OT

ÿ **UC1:** Login to the web store ÿ Primary

participant: User

ÿ Stakeholders and interests: User - wants to buy

products ÿ Prerequisites: User has access to the web

ÿ Consequences: User sees his account, can pay and deliver ÿ Summary: User

accesses the system via username and password

ÿ **MUC1:** Password sniffing

ÿ Primary participant: Attacker ÿ

Stakeholders and interests: Attacker - wants to obtain user credentials ÿ

Prerequisites: Attacker has access to the machine or network path to the

system ÿ Consequences: Attacker has obtained one or more valid usernames /

passwords ÿ Summary: Attacker obtains and later abuses unauthorized system access

An example of a MUC scenario

ÿ **Basic flow:**

1. The attacker installs a network sniffer 2.

The sniffer saves packets containing "Logon", "Username", "Password"

3. The attacker reads the sniffer logs

4. The attacker finds the correct *login / password*

5. The attacker uses the found *login / password* to access the system

ÿ **Alternative streams:**

1a: The attacker is not in the path between the user and

the system 1a1. An attacker uses *ARP poisoning* or similar to redirect packets

1b: The attacker uses a wireless connection

1b1. The attacker goes to the user's location

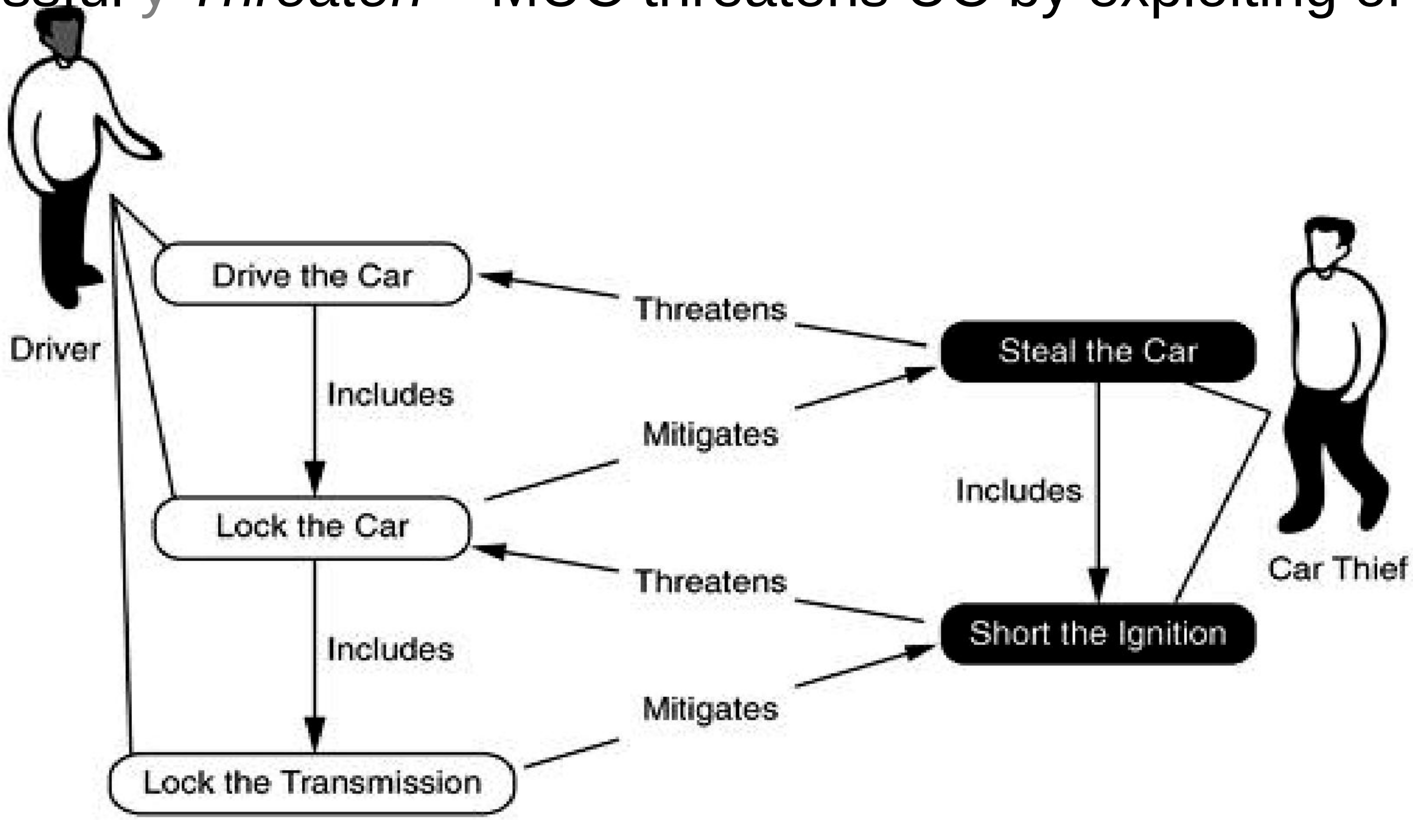
1b2. The attacker uses a *wifi sniffer* to intercept traffic

Linking cases of abuse

ÿ Extending the use case diagram

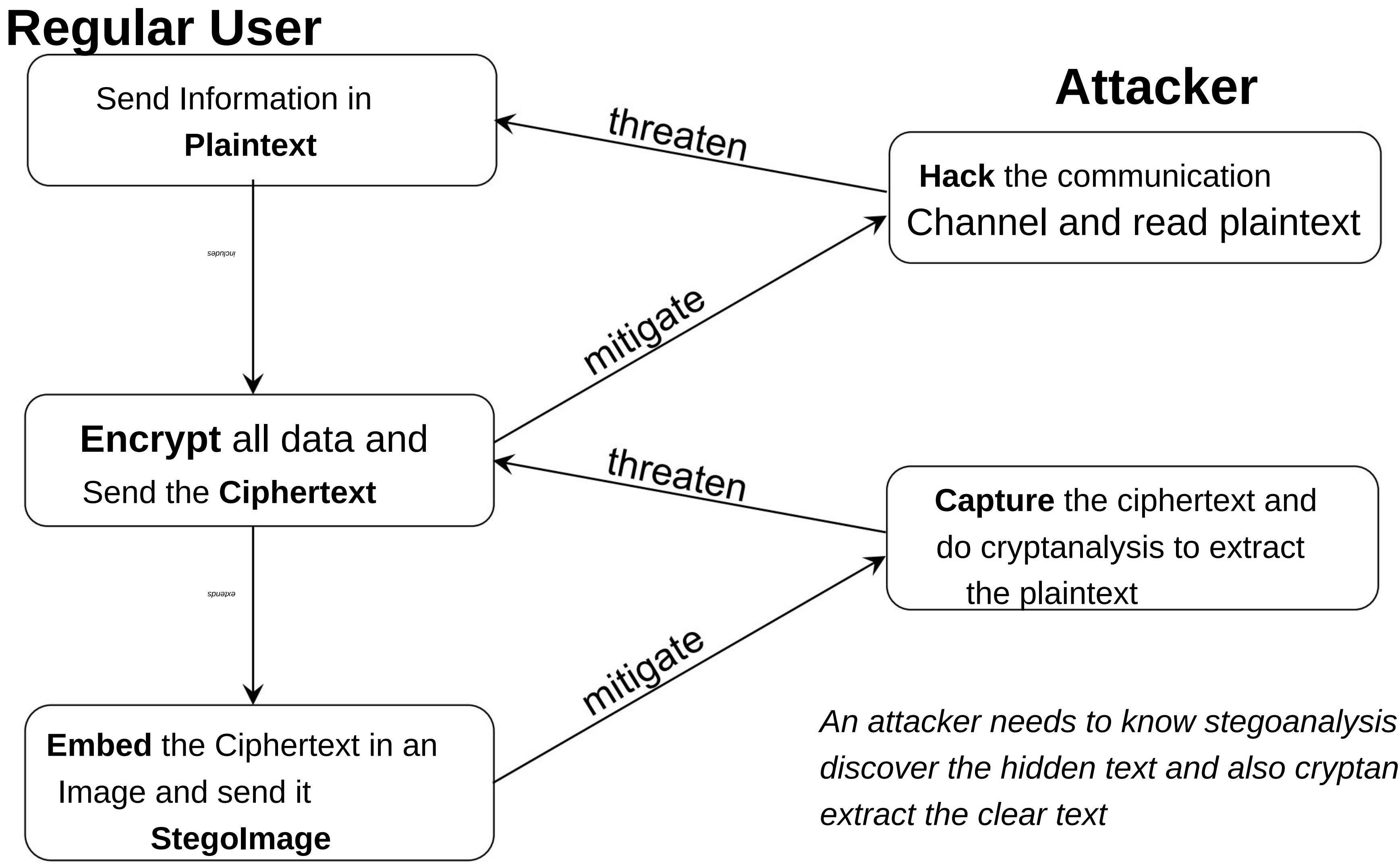
ÿ *Mitigate* – UC reduces the chance for MUC to be

successful ÿ *Threaten* – MUC threatens UC by exploiting or inhibiting it



M. Imran Daud, "Secure Software Development Model: A Guide for Secure Software Life Cycle," Proceedings of the International Multi Conference on Engineers and Computer Scientists, vol. I,

Example: UC-MUC secure communication diagram



Regular User

Send Information in **Plaintext**

Encrypt all data and Send the **Ciphertext**

Embed the Ciphertext in an Image and send it **StegoImage**

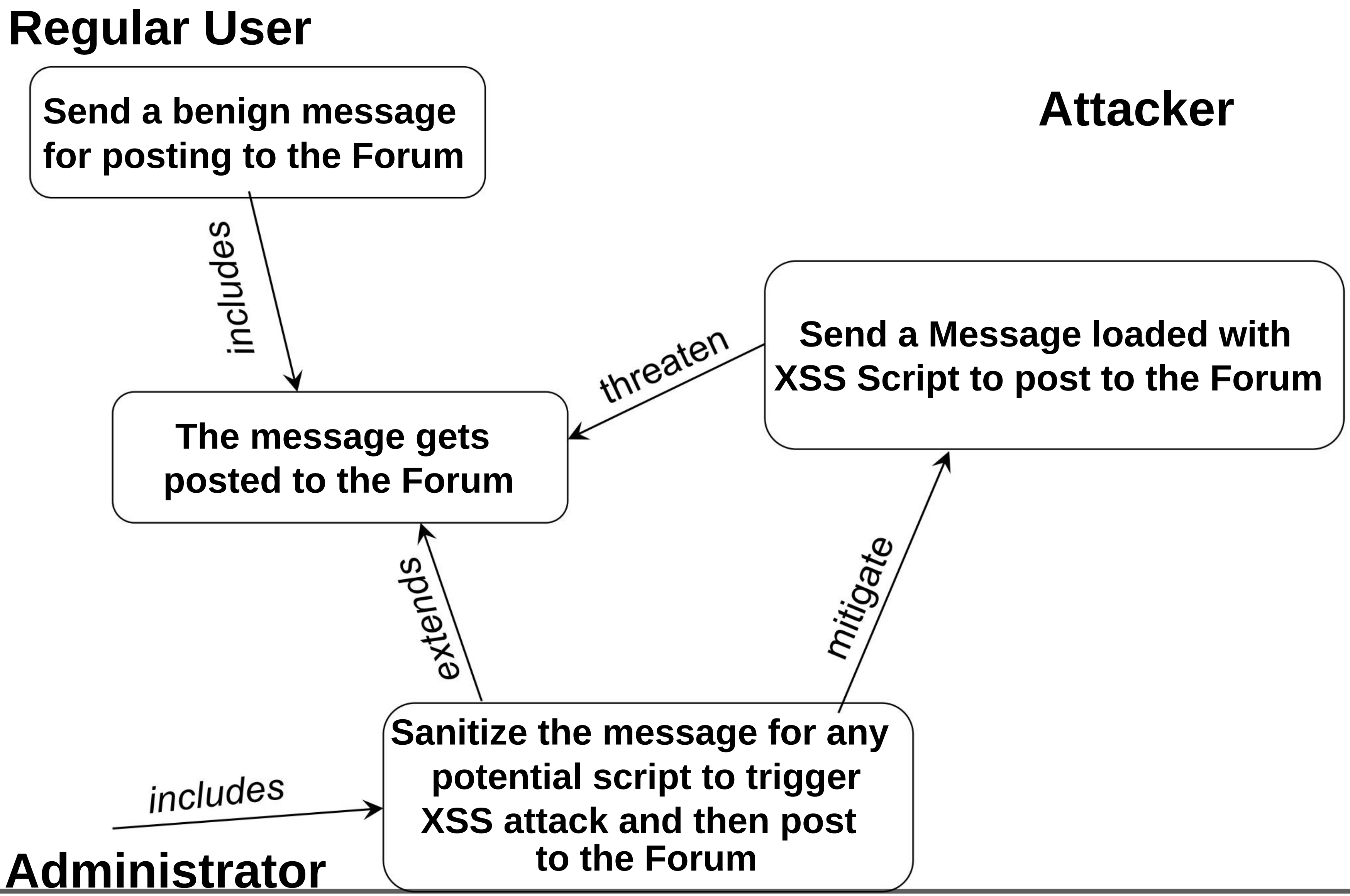
Attacker

Hack the communication Channel and read plaintext

Capture the ciphertext and do cryptanalysis to extract the plaintext

An attacker needs to know stegoanalysis to discover the hidden text and also cryptanalysis to extract the clear text

Example: UC-MUC diagram for a web forum



Regular User

Send a benign message for posting to the Forum

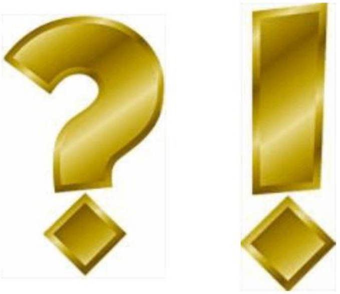
The message gets posted to the Forum

Attacker

Send a Message loaded with XSS Script to post to the Forum

Sanitize the message for any potential script to trigger XSS attack and then post to the Forum

Administrator



Tools for software security (not network)

ÿ Microsoft SDL and derivatives

1

ÿ Attack Surface Analyzer – reducing the attack surface

ÿ Microsoft Threat Modeling Tool – threat modeling ÿ
MiniFuzz basic file fuzzing tool – *fuzz* testing ÿ Regular
expression file fuzzing tool – testing of potential DoS vulnerabilities

ÿ Static analysis

ÿ StyleCop https://stylecop.codeplex.com/ # similar, FxCop

ÿ CodeSmart http://www.axtools.com/ ÿ NDepend http://
www.ndepend.com/ ÿ PMD Java, Checkstyle, FindBugs+Find
Security Bugs

Resources

ÿ Open Web Application Security Project (OWASP) ÿ http://
www.owasp.org, OWASP Top Ten vulnerabilities in web applications.

ÿ Building Security In ÿ https://buildsecurityin.us-cert.gov/bsi/home.html ÿ
SANS Institute ÿ http://www.sans.org/ , CWE/SANS Top 25 Most
Dangerous Prog. Errors ÿ CERT (Computer Security Incident Response
Team)

ÿ http://www.cert.org/ , http://www.cert.org/secure-coding/, https://www.cert.hr

ÿ Cloud Security Alliance ÿ https://cloudsecurityalliance.org/ ÿ Other ÿ CVE
(Common Vulnerabilities and Exposures), http://cve.mitre.org/ ÿ Security
Tracker, http://securitytracker.com/ ÿ US-CERT Cyber Security Bulletins http://
www.us-cert.gov/cas/bulletins/ ÿ Web Application Security Consortium
(WASC), http://www.security webappsec.org/ ÿ MSDN, http://msdn.microsoft.com/

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ÿ BSIMM Building Security In – Maturity Model, http://bsimm.com

ÿ OpenSAMM Software Assurance Maturity Model, http://opensamm.org

ÿ OWASP Application Threat Modeling

ÿ https://www.owasp.org/index.php/Application_Threat_Modeling

For the end

ÿ Bruce Schneier, https://www.schneier.com/

- ÿ If you think technology can solve your security problems, then you don't understand the problems and you don't understand the technology.

- ÿ Unless you think like an attacker, you will be unaware of any potential threats!

- ÿ You can't defend. You can't prevent it. The only thing you can do is detect and respond.