Software Security testing

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INTRODUCTION

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What is Security testing ?

*"Software security is simply about the process of **building secure software** by designing software to be secure, **emphasizing** that the software is secure, and **educating** software architects, developers, and users about **how to build and use secure things**." - G. McGraw [1]*

*Software Security is the software's **ability to highly resist**, **tolerate**, and **recover** from cases that strongly **threaten** the product." - Julia Allen[2]*

Why Security testing ?

*Helps in **identifying weaknesses and security risks at earlier stage.***

RISKS AND OBSERVATIONS

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Risks

Loss of **ability**

Loss of access to business-critical information

Loss of **customer trust**

Damage to company **reputation**

Lead to **fines and sanctions**

Observations

46% of businesses lost sensitive data.

90% of businesses admitted security incident

Enterprises lose **half a million US dollars** on average due to security breaches

https://media.kaspersky.com/pdf/it-risks-survey-report-cost-of-security-breaches.pdf

CIA TRIAD

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Information is not **disclosed** to **unauthorized** individuals, processes, or devices.

Confidentiality

Data is **unchanged, not modified or destroyed.**

Integrity

Guarantees **timely and reliable access** to data and information services.

Availability

Ref : Michael Felderer et al. A classification for model-based security testing". In: Advances in System Testing and Validation Lifecycle (VALID 2011)] (2011), pp. 109-114.

REQUIREMENTS FOR SECURITY TESTING

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- Identification Requirements
- System Maintenance Security Requirements
- Survivability Requirements
- Security Auditing Requirements
- Privacy Requirements
- Non-repudiation Requirements
- Intrusion Detection Requirements
- Integrity Requirements
- Immunity Requirements

Ref: Donald Firesmith et al. "Engineering security requirements."

CHALLENGES IN SECURITY TESTING

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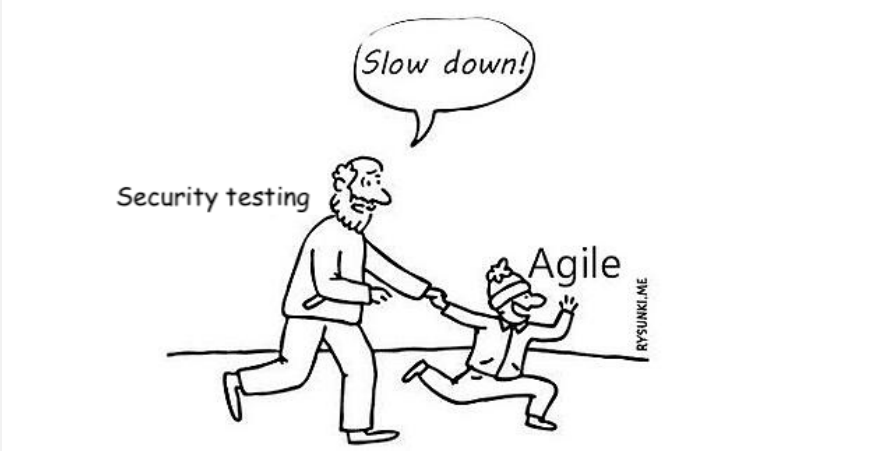
- **Fast paced Development :**
  - Fast paced development can lead to bypassing security requirements.
- **Risks of Using Open/Commercial Source Components :**
  - Using without/little knowledge can lead to vulnerability and unwanted complexity.
- **Vulnerabilities in Code :**
  - Developed Application can have vulnerabilities due to weakness in languages.
  - Can create challenges in applying security policies



C language **buffer overflow error, format string vulnerability, integer errors.**

Ref: https://americansecuritytoday.com/secure-software-development-challenges-and-considerations/

CHALLENGES IN SECURITY TESTING

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- **Lack of AppSec Planning :**
  - Can lead to unmanageable security issues and unclear requirement .

Ref: https://speakerstudio.typepad.com/.a/6a0134828b4555970c0134884f221f970c-pi

TECHNIQUES OF SECURITY TESTING IN SDLC

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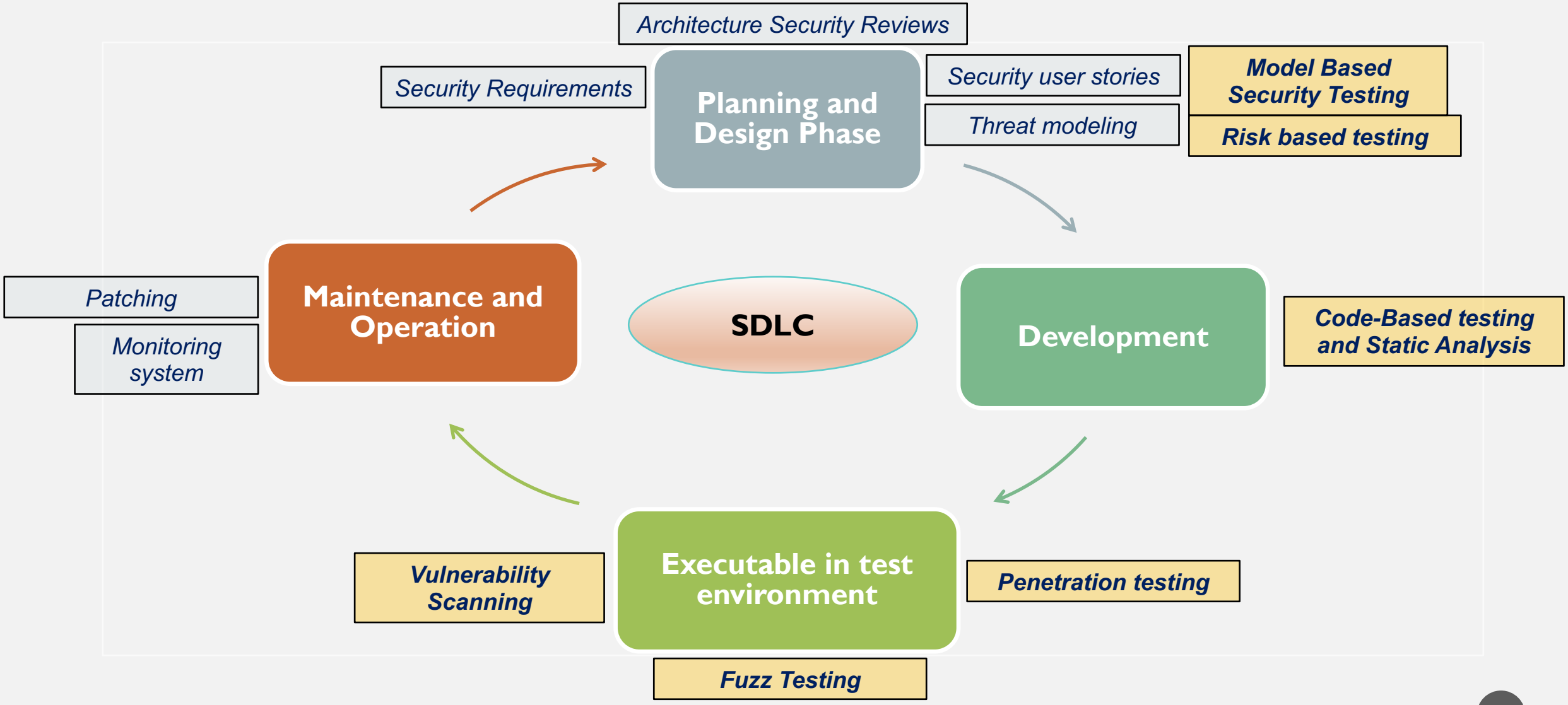

RISK-BASED SECURITY TESTING

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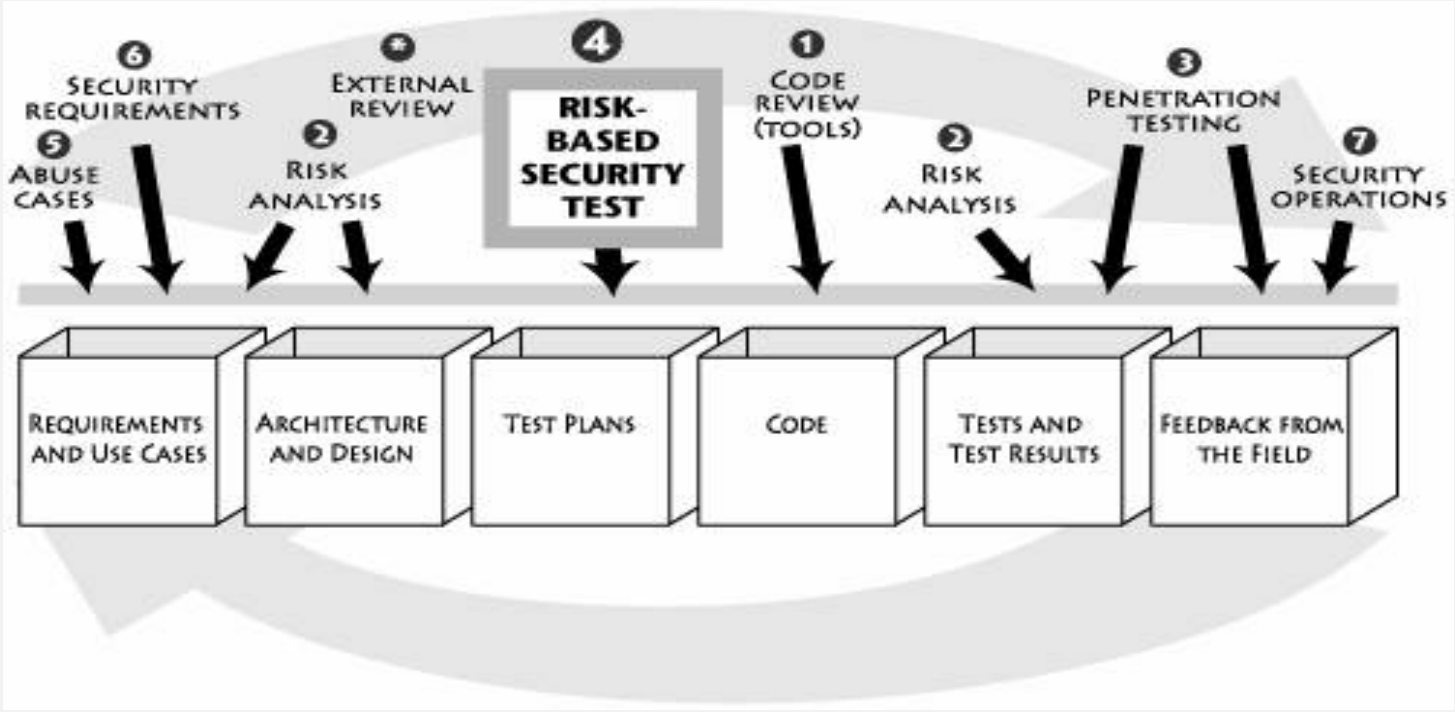
- Optimizing process by **risk analysis**.
- Introduces the notion of **risk values**.
- Enable to **weigh test scenarios**.
- Emphasis on **negative requirements** or **abuse cases**.
- Provide **evidence** on the **functional correctness** of countermeasures and **absence of Known vulnerabilities**.
- Discovering **unknown vulnerabilities** at early stage.



Ref: IEEE Security & Privacy magazine co-authored with Bruce Potter [Potter and McGraw 2004].

RISK-BASED SECURITY TESTING

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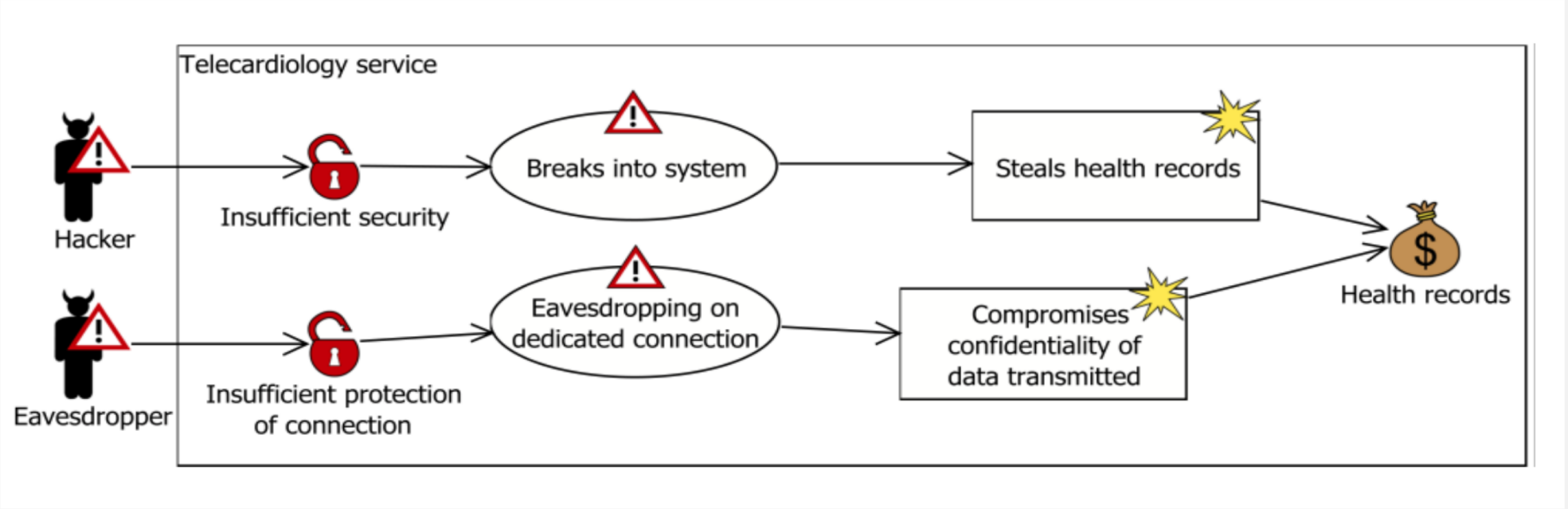
- CORAS model-based method for security risk analysis.



Initial threat diagram: deliberate actions

Ref: CORAS-handbook-v1.0

MODEL BASED SECURITY TESTING

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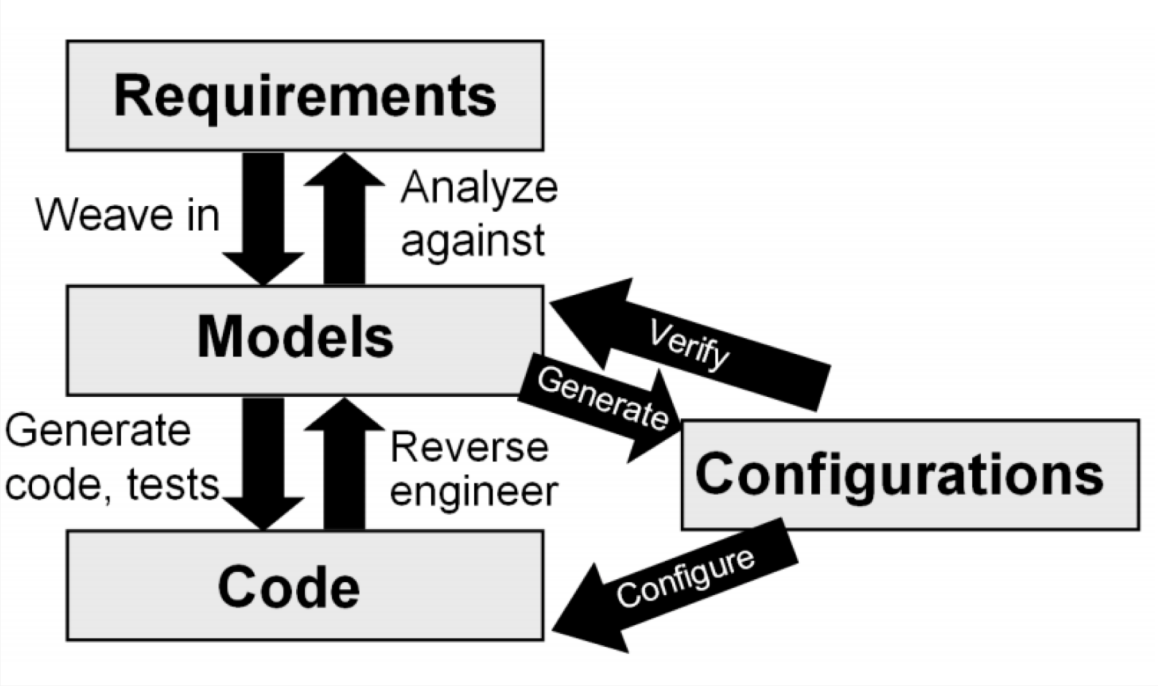
- Relies on models.
- Generating **test cases automatically** from models(set of models).
- **Early vulnerability detection**.
- UMLsec modelling language for security testing.
- Reveal attacks which are visible only at model level. Mutations testing can reveal those.



Ref *: Jan Jurjens. Model-based security testing using umlsec: A case study".In: Electronic Notes in Theoretical Computer Science 220.1 (2008)
**: Guido Wimmel and Jan Jurjens. Specication-based test generation for security-critical systems using mutations". In: International Conference on Formal Engineering Methods. Springer. 2002, pp. 471-482.

MODEL BASED SECURITY TESTING

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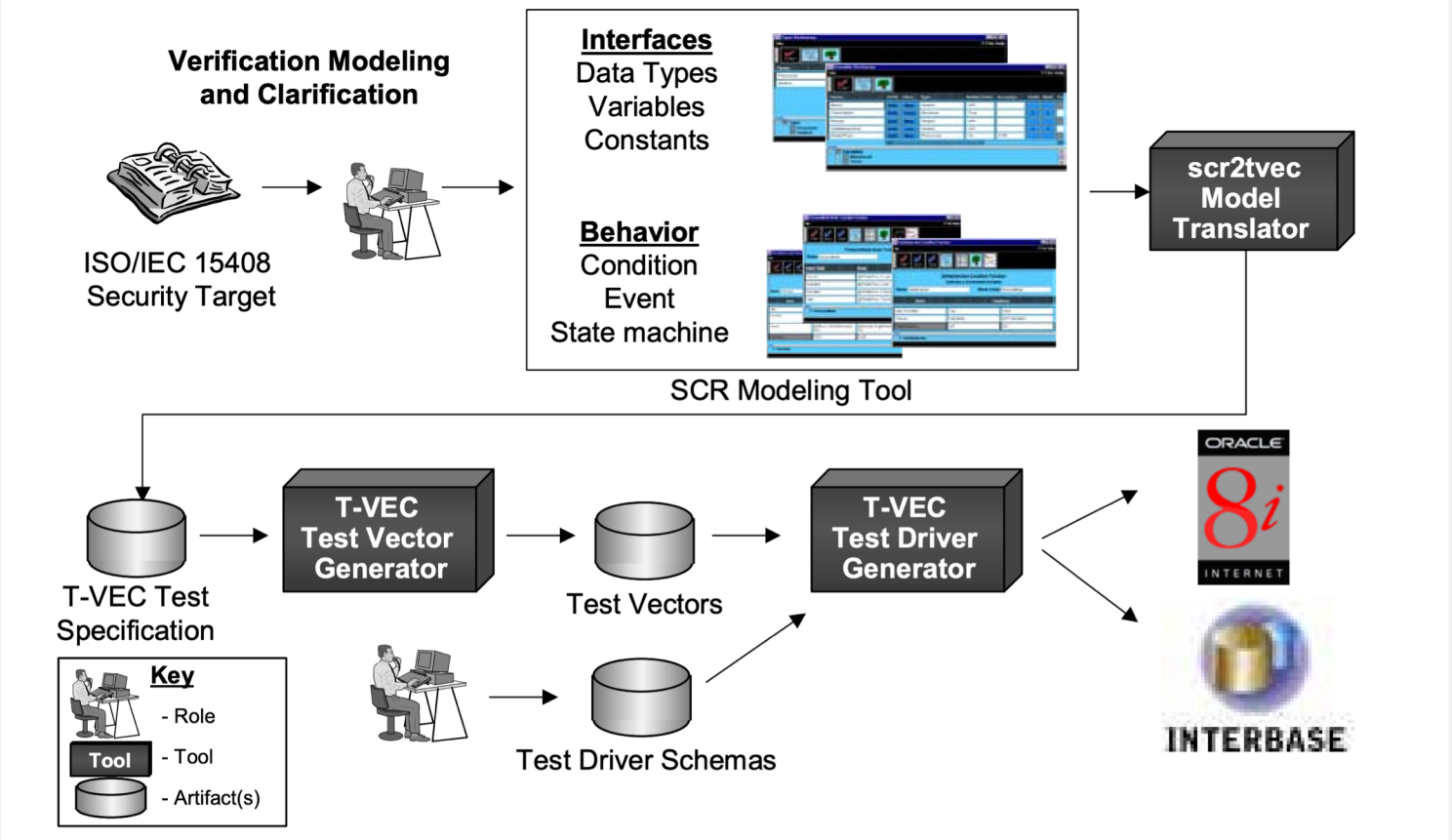
- Developing models of security function specification to generate automatic test vector and test driver generation.
- And, then by using schemas, generating test cases.



Model-based Approach to Security Test Automation

Ref : Mark Blackburn et al. Model-based approach to security test automation". In: Proceeding of Quality Week 2001. 2001

CODE-BASED TESTING AND STATIC ANALYSIS

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- Analyzing code **without execution (White Box security testing).**
- Powerful in detecting vulnerabilities in source code.
- **Strength :**
  - Reveal concurrency problems, time bombs, logic bombs, flawed business logic and many more.
  - Back doors, trojans, and other forms of malicious code can be exposed.
  - Scales well – can ran on lots of software
  - Real time feedback to developers.
  - Early bugs
- **Weakness:**
  - False positive
  - Infeasible to detect run-time errors
  - Unable to detect authentication, cryptography, access control issues.

CODE-BASED TESTING AND STATIC ANALYSIS

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- **Principle**: Deducing, Data flow analysis(DFA), Control Flow Graph (CFG), Taint analysis and Lexical analysis.
- DFA tries to collect **run-time information** of data in software **in a static state**(Wögerer-2005).
- DFA common terms are **basic block** (the code), **Control Flow Analysis** (the flow of data) **and Control Flow Path** (the path the data takes).
- **Lexical analysis**: preprocess and tokenize of source and then match token stream against a library of vulnerable constructs.
- **Tools** : ITS4, FlawFinder RATS , Veracode

```
$a = 0;
$b = 1;

if ($a == $b)
{ # start of block
  echo “a and b are the same”;
} # end of block
else
{ # start of block
  echo “a and b are different”;
} # end of block
```

PHP basic block

Ref: https://owasp.org/www-community/controls/Static_Code_Analysis

Ref: Wögerer W. A survey of static program analysis techniques. Tech. rep., Technische Universität Wien; 2005 Oct 18.

PENETRATION TESTING

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- Tester attempts **to compromise the security features** of a system **based on their understanding** of the system design and implementation.
- **Hacking own system before someone else.**
- **Types :** black-box, white-box, and grey-box
- **Strength :**
  - Can identify a range of vulnerabilities including high-risk weaknesses.
  - Unable to reveal both unknown and known hardware or software flaws.
  - Enables a proactive security approach.
- **Weakness:**
  - Demands deep knowledge and imaginations.
  - Can give false sense of security.

PENETRATION TESTING

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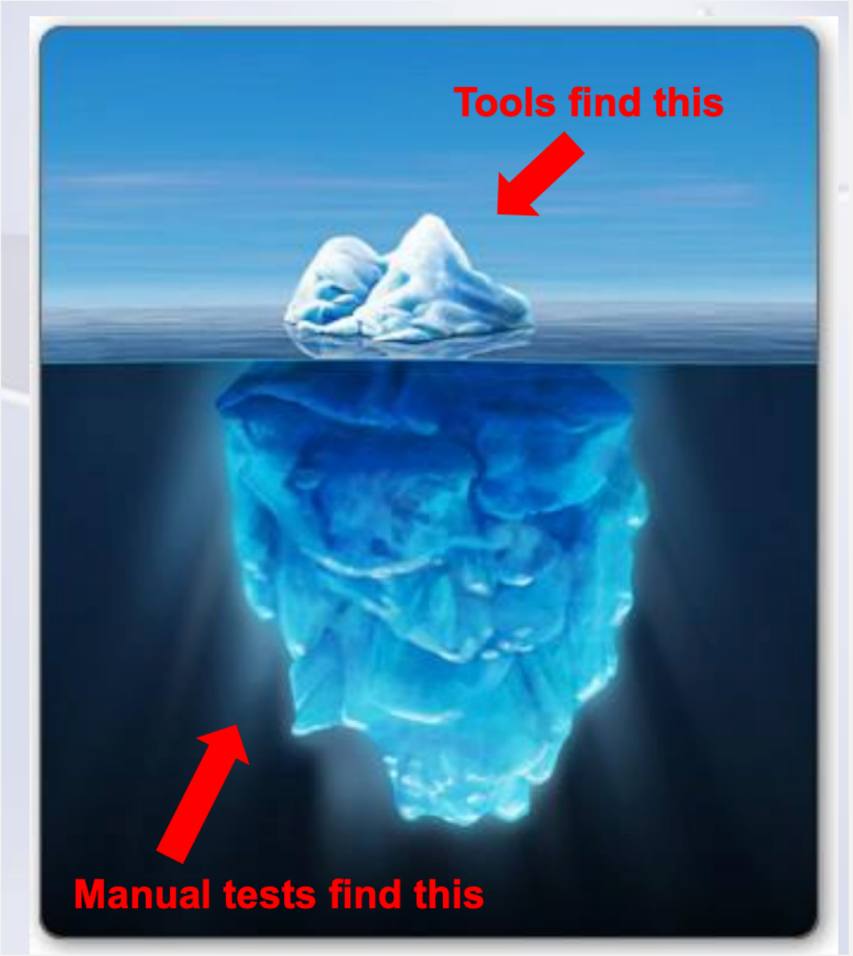
- Popular penetration testing methodologies are :
  - OSSTMM (Open Source Security Testing Methodology Manual)
  - OWASP (Open Web Application Security Project)
  - NIST (National Institute of Standards and Technology)
  - PTES (Penetration Testing Methodologies and Standards)
  - ISSAF (Information System Security Assessment Framework)
- **Tools:** Wireshark, Kali linux, Metasploit, OSWAP, Ettercap, Nmap etc.



VULNERABILITY SCANNING

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- Automatically scans for software security risks, testing space and known defects.
- For ex. network port scanning reveal vulnerable ports.
- Vulnerability scanning look for known vulnerability signature or pattern.
- **Strength** :
  - Faster result because of automated scanning tools.
  - Can be performed any time.
  - Save time.
- **Weakness**:
  - Only identifies known vulnerabilities.
  - False Positive.

VULNERABILITY SCANNING

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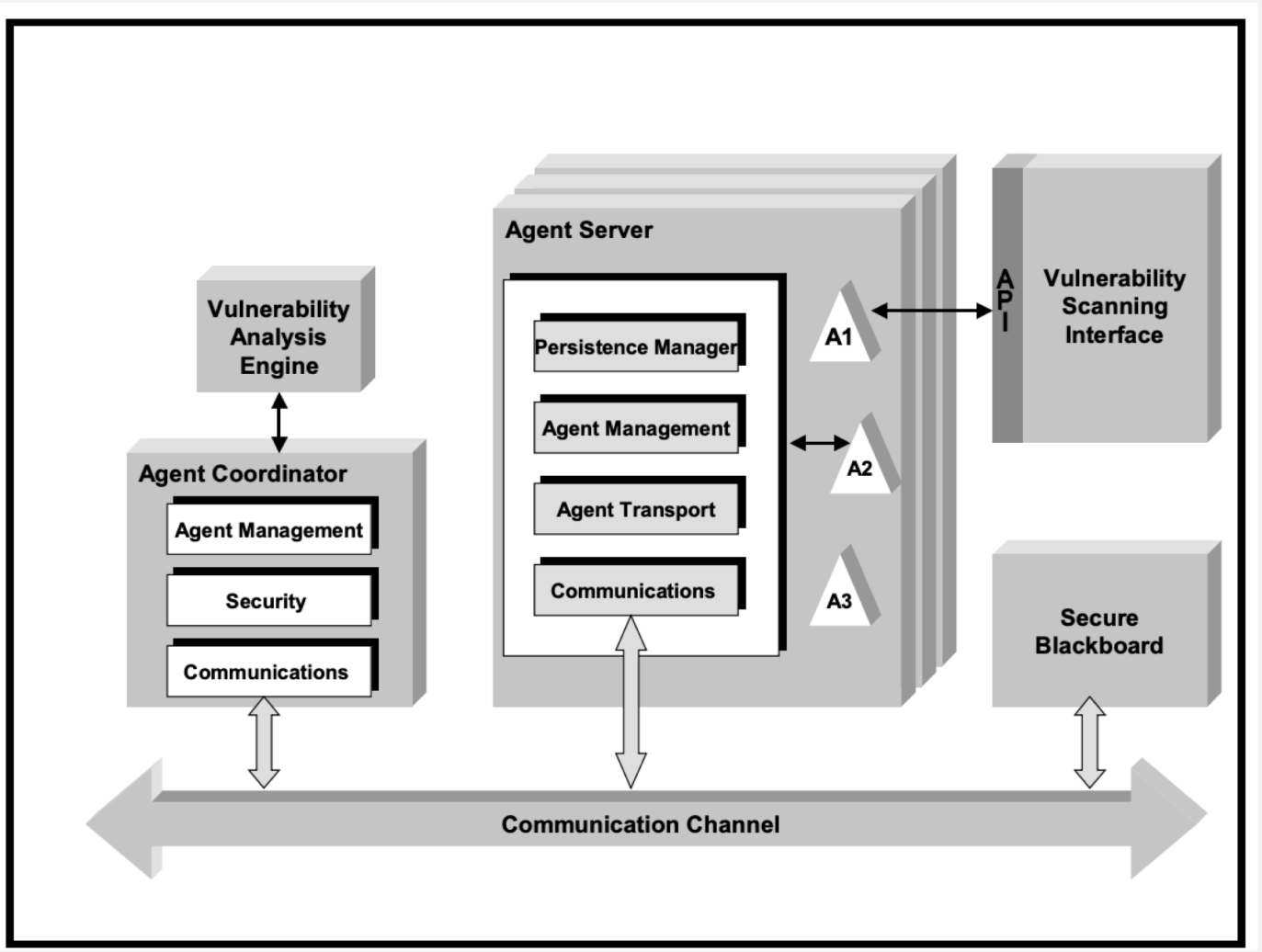
- **Tools**:
  - Security Prole Inspector (SPI)
  - Internet Security Scanner (ISS)
  - Security Analysis Tool for Auditing Network (SATAN)
  - Tiger
  - Sscan
  - Nmap
  - COPS
  - Tripwire.
- Jeffrey W. Humphries et at. proposed vulnerability scanning system using secure mobile agents that is easy to customize and is also resistant to attack.



Ref*: Jerey W Humphries, Curtis A Carver Jr, and Udo W Pooch. Secure mobile agents for network vulnerability scanning". In: Proceedings of the Software Security Testing 21 2000 IEEE Workshop on Information Assurance and Security. 2000, pp. 6-7.

FUZZ TESTING

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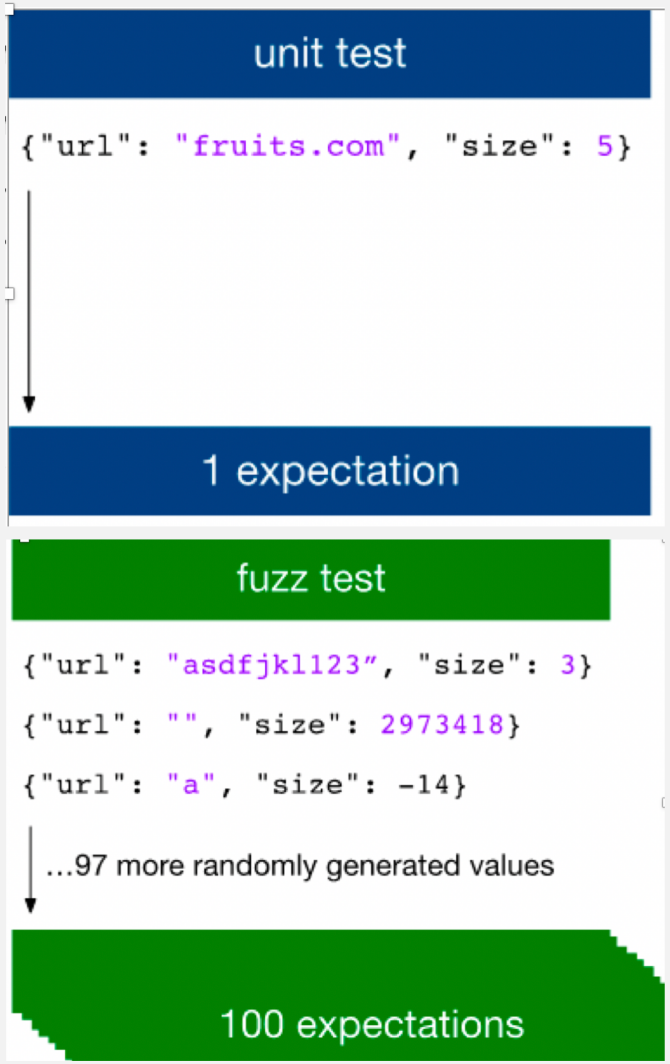
- Injecting **semi-random/random data** into a **SUT** in search of unexpected behavior.
- **Strength :**
  - Finds flaws which are difficult to get via logical methods.
  - Very less computational cost and time.
  - Best for SQL injection, buffer overflow, denial of service(DOS) and cross site scripting.
- **Weakness:**
  - Demands deep knowledge and imaginations.
  - Can give false sense of security.



https://freecontent.manning.com/writing-fuzz-tests-in-elm/

FUZZ TESTING

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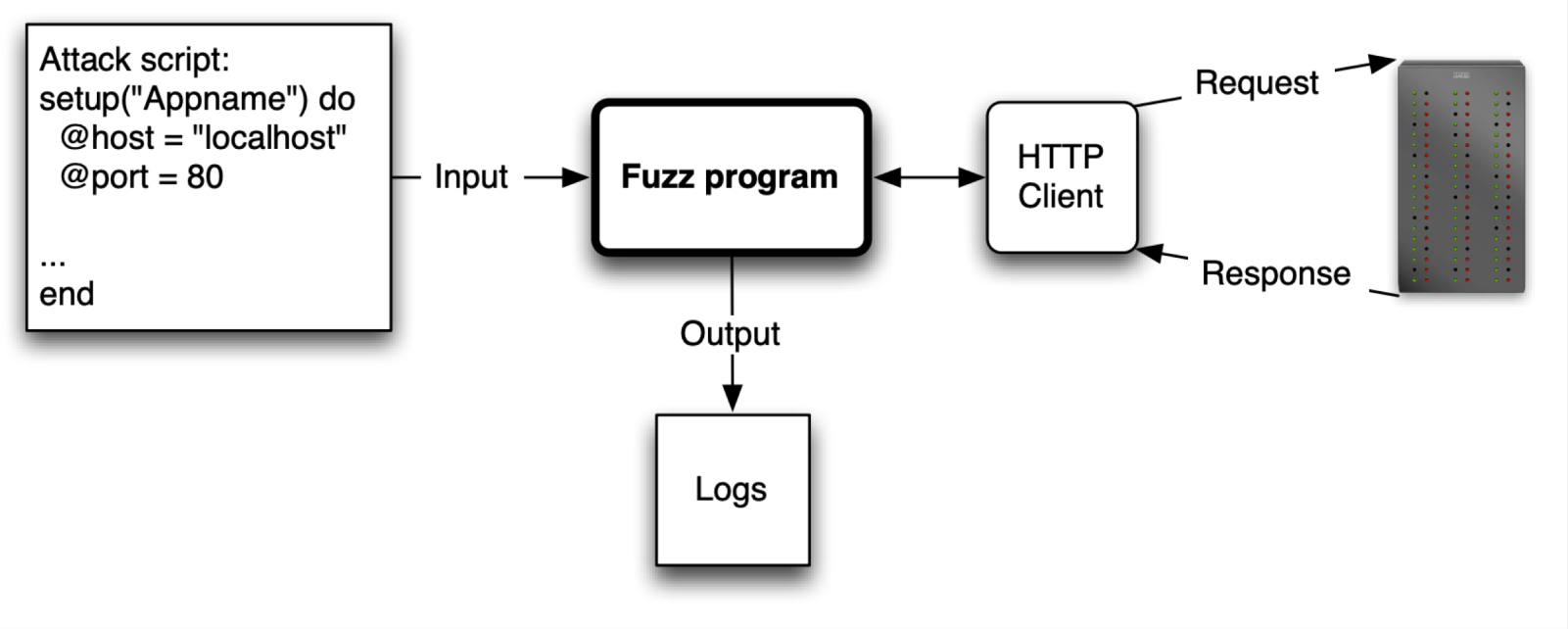
- **Tools:**
  - JBroFuzz
  - WSFuzzer
  - American fuzzy lop
  - Radamsa - a flock of fuzzers
  - Microsoft SDL MiniFuzz File Fuzzer
- Rune Hammersland et al. proposed method to (semi) automatic generation of pseudo random test data (fuzzing) for web application.



Ref : Hammersland, Rune, and Einar Snekkenes. "Fuzz testing of web applications." *Retrieved* 7.16 (2008): 2010.

SELECTION CRITERIA FOR TOOLS

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- **Attack surface** : Total vulnerability that can be exploited.
- **Application type** : Web based, Desktop, Mobile app, Cloud based, firmware etc.
- **Quality of results and usability :** False positive rate, scalability, maintainability etc.
- **Supported technologies :** programming languages, interfaces etc.
- **Performance and resource utilization :** Man power, computational power etc.
- **Costs for licenses, maintenance, and support**

Ref: Michael Felderer et al. Security testing: A survey". In: Advances in Computers. Vol. 101. Elsevier, 2016

MINDSET FOR SECURITY TESTING

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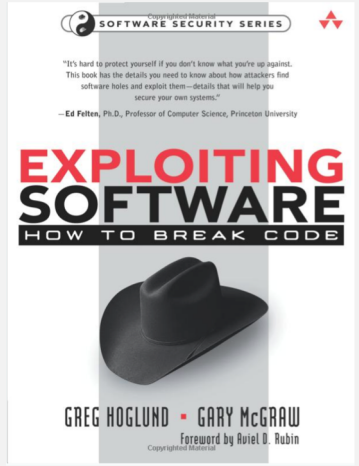
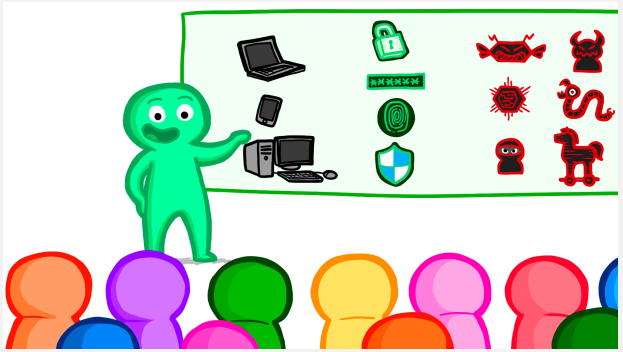
- Security mindset makes better tester.
- Some key aspect required for security testing are :
  - **Extensive knowledge of the domain.**
  - **Imagination**
  - **An attacker mindset**





https://www.csforallteachers.org/event/teaching-cybersecurity-csp-or-any-cs-class-introducing-security-mindset

Ref: Sara Hooshangi, Richard Weiss, and Justin Cappos. "Can the security mindset make students better testers?" In: Proceedings of the 46th ACM Technical Symposium on Computer Science Education. 2015

CONCLUSION

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- Organizations have to **focus equally or more** on the security aspect of the applications.
- **Test as early as possible.**
- **Adopt to systematic approaches**/frameworks of security testing.
- **Utilize tools** in fast paced SDLC.
- More **focused research on latest technologies** like ubiquitous computing, semantic web, HTML5.
- **Automation** of security testing **demands** focus, especially **usability aspect**.
- Vulnerability not only security flaws, it can be **unexpected but intentional misuse of application**.
- Tester have to be **creative** and **have mindset of attacker**.
- Fully integrated testing tool for model based testing is still a long way.

REFERENCES

UNIVERSITÄT KOBLENZ · LANDAU

1. G. McGraw. Software security". In: IEEE Security Privacy 2.2 (2004)
2. Jason Bau et al. \State of the art: Automated black-box web application vulnerability testing"
3. https://www.stickyminds.com/article/shift-left-approach-software-testing
4. https://americansecuritytoday.com/secure-software-development-challenges-and-considerations/
5. Michael Felderer et al. A classification for model-based security testing". In: Advances in System Testing and Validation Lifecycle (VALID 2011)] (2011), pp. 109-114.
6. Ina Schieferdecker, Juergen Grossmann, and Martin Schneider. Model based security testing".
7. Donald Firesmith et al. "Engineering security requirements."
8. Jan Jurjens. Model-based security testing using umlsec: A case study".In: Electronic Notes in Theoretical Computer Science 220.1 (2008).
9. Jerey W Humphries, Curtis A Carver Jr, and Udo W Pooch. Secure mobile agents for network vulnerability scanning". In: Proceedings of the Software Security Testing 21 2000 IEEE Workshop on Information Assurance and Security. 2000, pp. 6-7
10. Wögerer W. A survey of static program analysis techniques. Tech. rep., Technische Universität Wien; 2005 Oct 18.
11. Guido Wimmel and Jan Jurjens. \Specification-based test generation for security-critical systems using mutations". In: International Conference on Formal Engineering Methods. Springer. 2002, pp. 471-482.
12. Jerey W Humphries, Curtis A Carver Jr, and Udo W Pooch. Secure mobile agents for network vulnerability scanning". In: Proceedings of the Software Security Testing 21 2000 IEEE Workshop on Information Assurance and Security. 2000, pp. 6-7.
13. Hammersland, Rune, and Einar Snekkenes. "Fuzz testing of web applications." *Retrieved* 7.16 (2008): 2010.
14. Petar Tsankov, Mohammad Torabi Dashti, and David Basin. SECFUZZ: Fuzz-testing security protocols". In: 2012 7th International Workshop on Automation of Software Test (AST). IEEE. 2012, pp. 1-7.
15. Sara Hooshangi, Richard Weiss, and Justin Cappos. "Can the security mindset make students better testers?" In: Proceedings of the 46th ACM Technical Symposium on Computer Science Education. 2015

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THANK YOU !