



# Common Attack Pattern Enumeration and Classification (CAPEC)

## Status Update

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# Common Attack Pattern Enumeration and Classification (CAPEC)

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- **Community effort targeted at:**
  - Standardizing the capture and description of attack patterns
  - Collecting known attack patterns into an integrated enumeration that can be consistently and effectively leveraged by the community
  - Gives you an attacker's perspective you may not have on your own
  - Initially, attack-centric testing methods, now building to network behavior...
- **Excellent resource for many key activities**
  - Abuse Case development
  - Architecture attack resistance analysis
  - Risk-based security/Red team penetration testing
  - Whitebox and Blackbox testing correlation
  - Operational network observation correlation
- <http://capec.mitre.org>



CAPEC - Common Attack Pattern Enumeration and Classification (CAPEC)

http://capec.mitre.org/ Google

# CAPEC Common Attack Pattern Enumeration and Classification

A Community Knowledge Resource for Building Secure Software

Search by ID:  Go

**CAPEC List**

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- Methods of Attack View

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**Community**

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Building software with an adequate level of security assurance for its mission becomes more and more challenging every day as the size, complexity, and tempo of software creation increases and the number and the skill level of attackers continues to grow. These factors each exacerbate the issue that, to build secure software, builders must ensure that they have protected every relevant potential vulnerability; yet, to attack software, attackers often have to find and exploit only a single exposed vulnerability. To identify and mitigate relevant vulnerabilities in software, the development community needs more than just good software engineering and analytical practices, a solid grasp of software security features, and a powerful set of tools. All of these things are necessary but not sufficient. To be effective, the community needs to think outside of the box and to have a firm grasp of the attacker's perspective and the approaches used to exploit software.

Attack patterns are a powerful mechanism to capture and communicate the attacker's perspective. They are descriptions of common methods for exploiting software. They derive from the concept of design patterns applied in a destructive rather than constructive context and are generated from in-depth analysis of specific real-world exploit examples.

To assist in enhancing security throughout the software development lifecycle, and to support the needs of developers, testers and educators, the **Common Attack Pattern Enumeration and Classification (CAPEC)** is sponsored by the Department of Homeland Security as part of the Software Assurance strategic initiative of the National Cyber Security Division. The objective of this effort is to provide a publicly available catalog of attack patterns along with a comprehensive schema and classification taxonomy. This site now contains the initial set of content and will continue to evolve with public participation and contributions to form a standard mechanism for identifying, collecting, refining, and sharing attack patterns among the software community.

**Release 1.4 Available**

Page Last Updated: September 22, 2009

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## Individual CAPEC Dictionary Definition (Release 1.2)

### Blind SQL Injection



**Attack Pattern ID** 7

**Pattern Abstraction:** Detailed

**Typical Severity** High

#### **Description** Summary

Blind SQL Injection results from an insufficient mitigation for SQL Injection. Although suppressing database error messages are considered best practice, the suppression alone is not sufficient to prevent SQL Injection. Blind SQL Injection is a form of SQL Injection that overcomes the lack of error messages. Without the error messages that facilitate SQL Injection, the attacker constructs input strings that probe the target through simple Boolean SQL expressions. The attacker can determine if the syntax and structure of the injection was successful based on whether the query was executed or not. Applied iteratively, the attacker determines how and where the target is vulnerable to SQL Injection.

In order to achieve this using Blind SQL Injection, an attacker:

For example, an attacker may try entering something like "username' AND 1=1; --" in an input field. If the result is the same as when the attacker entered "username" in the field, then the attacker knows that the application is vulnerable to SQL Injection. The attacker can then ask yes/no questions from the database server to extract information from it. For example, the attacker can extract table names from a database using the following types of queries:

```
"username' AND ascii(lower(substring((SELECT TOP 1 name FROM sysobjects WHERE xtype='U'), 1, 1))) > 108".
```

If the above query executes properly, then the attacker knows that the first character in a table name in the database is a letter between m and z. If it doesn't, then the attacker knows that the character must be between a and l (assuming of course that table names only contain alphabetic characters). By performing a binary search on all character positions, the attacker can determine all table names in the database. Subsequently, the attacker may execute an actual attack and send something like:

```
"username'; DROP TABLE trades; --"
```



# A Few Key Use Cases for CAPEC in Support of SwA

- Help developers understand weaknesses in their real-world context (how they will be attacked)
- Objectively identify specific attacks under which software must demonstrate resistance, tolerance and resilience for a given level of assurance
- Indirectly scope which weaknesses are relevant for a given threat environment
- Identify relevant mitigations that should be applied as part of policy, requirements, A&D, implementation, test, deployment and operations
- Identify and characterize patterns of attacks for security test case generation
- Identify and characterize threat TTPs for red teaming
- Identify relevant issues for automated tool selection
- Identify and characterize issues for automated tool results analysis



# CAPEC Status

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## Where is CAPEC today?

- **V1.4**

- **Massive schema changes**
- **Some new content**
- **Added initial set of network attack patterns**

- **V1.5**

- **Added ~25 new network attack patterns**
- **Added enhanced material to ~35 patterns**
- **New View added for WASC Threat Taxonomy 2.0**
- **Added ~65 mappings to CWE and several within CAPEC**

**Currently 311 patterns, stubs, named attacks; 67 categories and 6 views**



# CAPEC Current Content (12 Major Categories)

## 1000 - Mechanism of Attack

- Data Leakage Attacks - (118)
- Resource Depletion - (119)
- Injection (Injecting Control Plane content through the Data Plane) - (152)
- Spoofing - (156)
- Time and State Attacks - (172)
- Abuse of Functionality - (210)
- Exploitation of Authentication - (225)
- Probabilistic Techniques - (223)
- Exploitation of Privilege/Trust - (232)
- Data Structure Attacks - (255)
- Resource Manipulation - (262)
- Network Reconnaissance - (286)





# CAPEC Current Content (Which Expand to...)

## 1000 - Mechanism of Attack

- Data Leakage Attacks - (118)
  - Data Excavation Attacks - (116)
  - Data Interception Attacks - (117)
- Resource Depletion - (119)
  - Violating Implicit Assumptions Regarding XML Content (aka XML Denial of Service (XDoS)) - (82)
  - Resource Depletion through Flooding - (125)
  - Resource Depletion through Allocation - (130)
  - Resource Depletion through Leak - (131)
  - Denial of Service through Resource Depletion - (227)
- Injection (Injecting Control Plane content through the Data Plane) - (152)
  - Remote Code Inclusion - (253)
  - Analog In-band Switching Signals (aka Blue Boxing) - (5)
  - SQL Injection - (66)
  - Email Injection - (134)
  - Format String Injection - (135)
  - LDAP Injection - (136)
  - Parameter Injection - (137)
  - Reflection Injection - (138)
  - Code Inclusion - (175)
  - Resource Injection - (240)
  - Script Injection - (242)
  - Command Injection - (248)
  - Character Injection - (249)
  - XML Injection - (250)
  - DTD Injection in a SOAP Message - (254)
- Spoofing - (156)
  - Content Spoofing - (148)
  - Identity Spoofing (Impersonation) - (151)
  - Action Spoofing - (173)
- Time and State Attacks - (172)
  - Forced Deadlock - (25)
  - Leveraging Race Conditions - (26)
  - Leveraging Time-of-Check and Time-of-Use (TOCTOU) Race Conditions - (29)
  - Manipulating User State - (74)
- Abuse of Functionality - (210)
  - Functionality Misuse - (212)
  - Abuse of Communication Channels - (216)
  - Forceful Browsing - (87)
  - Passing Local Filenames to Functions That Expect a URL - (48)
  - Probing an Application Through Targeting its Error Reporting - (54)
  - WSDL Scanning - (95)
  - API Abuse/Misuse - (113)
  - Try All Common Application Switches and Options - (133)
  - Cache Poisoning - (141)
  - Software Integrity Attacks - (184)
  - Directory Traversal - (213)
  - Analytic Attacks - (281)
- Probabilistic Techniques - (223)
  - Fuzzing - (28)
  - Manipulating Opaque Client-based Data Tokens - (39)
  - Brute Force - (112)
  - Screen Temporary Files for Sensitive Information - (155)

- Exploitation of Authentication - (225)
  - Exploitation of Session Variables, Resource IDs and other Trusted Credentials - (21)
  - Authentication Abuse - (114)
  - Authentication Bypass - (115)
  - Exploitation of Privilege/Trust - (232)
  - Privilege Escalation - (233)
  - Exploiting Trust in Client (aka Make the Client Invisible) - (22)
  - Hijacking a Privileged Thread of Execution - (30)
  - Subvert Code-signing Facilities - (68)
  - Target Programs with Elevated Privileges - (69)
  - Exploitation of Authorization - (122)
  - Hijacking a privileged process - (234)
- Data Structure Attacks - (255)
  - Accessing/Intercepting/Modifying HTTP Cookies - (31)
  - Buffer Attacks - (123)
  - Attack through Shared Data - (124)
  - Integer Attacks - (128)
  - Pointer Attack - (129)
- Resource Manipulation - (262)
  - Accessing/Intercepting/Modifying HTTP Cookies - (31)
  - Input Data Manipulation - (153)
  - Resource Location Attacks - (154)
  - Infrastructure Manipulation - (161)
  - File Manipulation - (165)
  - Variable Manipulation - (171)
  - Configuration/Environment manipulation - (176)
  - Abuse of transaction data structure - (257)
  - Registry Manipulation - (269)
  - Schema Poisoning - (271)
  - Protocol Manipulation - (272)
- Network Reconnaissance - (286)
  - ICMP Echo Request Ping - (285)
  - TCP SYN Scan - (287)
  - ICMP Echo Request Ping - (288)
  - Infrastructure-based footprinting - (289)
  - Enumerate Mail Exchange (MX) Records - (290)
  - DNS Zone Transfers - (291)
  - Host Discovery - (292)
  - Traceroute Route Enumeration - (293)
  - ICMP Address Mask Request - (294)
  - ICMP Timestamp Request - (295)
  - ICMP Information Request - (296)
  - TCP ACK Ping - (297)
  - UDP Ping - (298)
  - TCP SYN Ping - (299)
  - Port Scanning - (300)
  - TCP Connect Scan - (301)
  - TCP FIN scan - (302)
  - TCP Xmas Scan - (303)
  - TCP Null Scan - (304)
  - TCP ACK Scan - (305)
  - TCP Window Scan - (306)
  - TCP RPC Scan - (307)
  - UDP Scan - (308)



# CAPEC Current Content (311 Attacks...)

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# Linkage with Fundamental Changes in Enterprise Security Initiatives

## Twenty Critical Controls for Effective Cyber Defense Guidelines

What the 20 CSC Critics say...

20 Critical Security Controls - Version 2.0

- 20 Critical Security Controls - Introduction (Version 2.0)
- Critical Control 1: Inventory of Authorized and Unauthorized Devices
- Critical Control 2: Inventory of Authorized and Unauthorized Applications
- Critical Control 3: Secure Configurations for Hardware and Software
- Critical Control 4: Secure Configurations for Network Devices
- Critical Control 5: Boundary Defense
- Critical Control 6: Maintenance, Monitoring, and Analysis of Security Alerts
- Critical Control 7: Application Software Security
- Critical Control 8: Controlled Use of Administrative Privileges
- Critical Control 9: Controlled Access Based on Need to Know
- Critical Control 10: Data Protection
- Critical Control 11: Incident Response and Computer Forensics
- Critical Control 12: Business Continuity and Disaster Recovery
- Critical Control 13: Multi-Factor Authentication
- Critical Control 14: Security Awareness and Training
- Critical Control 15: Vendor Managed Security
- Critical Control 16: Penetration Testing
- Critical Control 17: Security Assessments
- Critical Control 18: Information Security Policies
- Critical Control 19: Security Incident Response and Computer Forensics
- Critical Control 20: Security Incident Response and Computer Forensics

## CAG: Critical Control 7: Application Software Security

<< previous control

Consensus Audit Guidelines

next control >>

### How do attackers exploit the lack of this control?

Attacks against vulnerabilities in web-based and other application software have been a top priority for criminal organizations in recent years. Application software that does not properly check the size of user input, fails to sanitize user input by filtering out unneeded but potentially malicious character sequences, or does not initialize and clear variables properly could be vulnerable to remote compromise. Attackers can inject specific exploits, including buffer overflows, SQL injection attacks, and cross-site scripting code to gain control over vulnerable machines. In one attack in 2008, more than 1 million web servers were exploited and turned into infection engines for visitors to those sites using SQL injection. During that attack, trusted websites from state governments and other organizations compromised by attackers were used to infect hundreds of thousands of

## CWE and CAPEC included in Control 7 of the “Twenty Critical Controls for Effective Cyber Defense: Consensus Audit Guidelines”


### Procedures and tools for implementing this control

Source code testing tools, web application security scanning tools, and object code testing tools have proven useful in securing application software, along with manual application security penetration testing by testers who have extensive programming knowledge as well as application penetration testing expertise. The Common Weakness Enumeration (CWE) initiative is utilized by many such tools to identify the weaknesses that they find. Organizations can also use CWE to determine which types of weaknesses they are most interested in addressing and removing. A broad community effort to identify the “Top 25 Most Dangerous Programming Errors” is also available as a minimum set of important issues to investigate and address during the application development process. When evaluating the effectiveness of testing for these weaknesses, the Common Attack Pattern Enumeration and Classification (CAPEC) can be used to organize and record the breadth of the testing for the CWEs as well as a way for testers to think like attackers in their development of test cases.

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**ISO/IEC JTC 1/SC 27 NXXXX**  
**ISO/IEC JTC 1/SC 27/WG x NXXXXX**

REPLACES: N

**ISO/IEC JTC 1/SC 27**  
**Information technology - Security techniques**  
 Secretariat: DIN, Germany

**DOC TYPE:** NB MWI Proposal for a technical report (TR)  
**TITLE:** National Body New Work Item Proposal on "Secure software development and evaluation under ISO/IEC 15406 and ISO/IEC 18405"  
**SOURCE:** INCITSACS 1, National Body of (US)  
**DATE:** 2006-09-30  
**PROJECT:** 15406 and 18405  
**STATUS:** This document is circulated for consideration at the forthcoming meeting of SC 27/WG 3 to be held in Redmond (WA, USA) on 2<sup>nd</sup> - 6<sup>th</sup> November 2006.  
**ACTION ID:** ACT  
**DUE DATE:**  
**DISTRIBUTION:** P, D and L-Members  
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**Common Criteria v4 CCDB**  
 •TOE to leverage CAPEC & CWE  
 •Also investigating how to leverage ISO/IEC 15026  
**NIAP Evaluation Scheme**  
 •Above plus  
 •Also investigating how to leverage SCAP

**New Work Item Proposal**  
**NP submitting**  
**PROPOSAL FOR A NEW WORK ITEM**

Date of presentation of proposal YYYY-MM-DD	Proposer: ISO/IEC JTC 1/SC 27
Secretariat National Body	ISO/IEC JTC 1 N XXXX ISO/IEC JTC 1/SC 27 N

**A proposal for a new work item shall be submitted to the secretariat of the ISO/IEC joint technical committee concerned with a copy to the ISO Central Secretariat.**  
**Presentation of the proposal**  
**Title** Secure software development and evaluation under ISO/IEC 15406 and ISO/IEC 18405

**Scope**  
 In the case where a target of evaluation (TOE) being evaluated under ISO/IEC 15406 and ISO/IEC 18405, includes specific software portions, the TOE developer may optionally present the developer's technical rationale for mitigating software common attack patterns and related weaknesses as described in the latest revision of the Common Attack Pattern Enumeration and Classification (CAPEC) model from <http://csrc.nist.gov>. The developer's technical rationale is expected to include a range of mitigation techniques, from architectural properties to design features, coding techniques, use of tools or other means.

**The Technical Report (TR) provides guidance for the developer and the evaluator on how to use the CAPEC as a technical reference point during the TOE development, the TOE design and in an evaluation of the TOE secure software under ISO/IEC 15406 and 18405, by addressing:**

- A refinement of the IS 15406 Attack Potential evaluation table for software, taking into account the entries contained in the CAPEC and their characteristic.
- How the information for mitigating software common attack patterns and related weaknesses is used in an IS 15406 evaluation, in particular providing guidance on how to determine which attack patterns and weaknesses are applicable to the TOE, taking into consideration of:
  - the TOE technology;
  - the TOE security problem definition;
  - the interfaces the TOE exports that can be used by potential attackers;
  - the Attack Potentials that the TOE needs to provide resistance for.
- How the technical rationale provided by the developer for mitigating software common attack patterns and related weaknesses is used in the evaluation of the TOE design and the development of test cases.
- How the CAPEC and related Common Weakness Enumeration (CWE) weaknesses are used by the evaluator, who needs to consider at the applicable attack patterns and be able to exploit specific related software weaknesses while performing the subsequent vulnerability analysis (AVA\_VAN) activities on the TOE.
- How incomplete entries from the CAPEC are resolved during an IS 15406 evaluation.
- How the evaluator's attack and weakness analysis of the TOE incorporates other attacks and weaknesses not yet documented in the CAPEC.

**The TR also investigates specific elements from the ISO/IEC 15026 (and its revision) are applicable to the guidelines being developed in the TR within the context of IS 15406 and 18405.**

# ISO/IEC JTC 1/SC 27/WG 3, NWP

## “Secure software development and evaluation under ISO/IEC 15408 and ISO/IEC 18405”



- The way how the CAPEC and related CWE taxonomies are to be used by the developer, which needs to consider and provide sufficient and effective mitigation to all applicable attacks and weaknesses.
- The way how the CAPEC and related CWE taxonomies are to be used by the evaluator, which needs to consider all the applicable attack patterns and be able to exploit all the related software weaknesses while performing the subsequent AVA\_VAN activities.
- How incomplete entries from the CAPEC are to be addressed during an evaluation.
- How to incorporate to the evaluation attacks and weaknesses not included in the CAPEC.

# Industry Uptake

## Manually review code after security education

Manual code review, especially review of high-risk code, such as code that faces the Internet or parses data from the Internet, is critical, but only if the people performing the code review know what to look for and how to fix any code vulnerabilities they find. The best way to help understand classes of security bugs and remedies is education, which should minimally include the following areas:

- C and C++ vulnerabilities and remedies, most notably buffer overruns and integer arithmetic issues.
- Web-specific vulnerabilities and remedies, such as cross-site scripting (XSS).
- Database-specific vulnerabilities and remedies, such as SQL injection.
- Common cryptographic errors and remedies.

Many vulnerabilities are programming language (C, C++ etc) or domain-specific (web, database) and others can be categorized by vulnerability type, such as injection (XSS and SQL Injection) or cryptographic (poor random number generation and weak secret storage) so specific training in these areas is advised.

### Resources

- A Process for Performing Security Code Reviews, Michael Howard, IEEE Security & Privacy July/August 2006.  
<http://msdn.microsoft.com/en-us/library/aa302432.aspx>
- .NET Framework Security — Code Review;  
<http://www.mscorlib.com/en-us/library/aa302432.aspx>
- **Common Weakness Enumeration, MITRE; <http://cwe.mitre.org/>**
- **Security Code Reviews;**  
[http://www.codesecurely.org/Wiki/view.aspx/Security\\_Code\\_Reviews](http://www.codesecurely.org/Wiki/view.aspx/Security_Code_Reviews)
- Security Code Review — Use Visual Studio Bookmarks To Capture Security Findings; <http://blogs.msdn.com/alki/archive/2008/01/24/security-code-review-use-visual-studio-bookmarks-to-capture-security-findings.aspx>
- Security Code Review Guidelines, Adam Shostack;  
<http://www.verber.com/mark/cs/security/code-review.html>
- OS WASP Top Ten; [http://www.owasp.org/index.php/OWASP\\_Top\\_Ten\\_Project](http://www.owasp.org/index.php/OWASP_Top_Ten_Project)

## Testing

Testing activities validate the secure implementation of a product, which reduces the likelihood of security bugs being released and discovered by customers and malicious users. The majority of SAFECode members have adopted the following software security testing practices in their software development lifecycle. This is not to “test in security,” but rather to validate the robustness and security of the software products prior to making the product available to customers. These testing methods do find security bugs, especially for products that may not have undergone critical secure development process changes.

## Fuzz testing

Fuzz testing is a reliability and security testing technique that relies on providing intentionally malformed data and then having the software under test consume the malformed data to see how it responds. The science of fuzz testing is somewhat new but it is maturing rapidly. There is a small market for fuzz testing tools today, but in many cases software developers must build bespoke fuzz testers to suit specialized file and network data formats. Fuzz testing is an effective testing technique because it uncovers weaknesses in data handling code.

### Resources

- Fuzz Testing of Application Reliability, University of Wisconsin;  
<http://pages.cs.wisc.edu/~bart/fuzz/fuzz.html>
- Automated Whitebox Fuzz Testing, Michael Levin, Patrice Godefroid and Dave Molnar, Microsoft Research;  
<ftp://ftp.research.microsoft.com/pub/tr/TR-2007-58.pdf>
- IANewsletter Spring 2007 “Look out! It’s the fuzzi!” Matt Warnock;  
[http://iac.dtic.mil/iatac/download/Vol10\\_No1.pdf](http://iac.dtic.mil/iatac/download/Vol10_No1.pdf)
- Fuzzing: Brute Force Vulnerability Discovery, Sutton, Greene & Amini, Addison-Wesley.
- **Open Source Security Testing Methodology Manual, ISECOM.**
- **Common Attack Pattern Enumeration and Classification, MITRE;**  
<http://capec.mitre.org/>



## Fundamental Practices for Secure Software Development A Guide to the Most Effective Secure Development Practices in Use Today

OCTOBER 8, 2008

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### CONTRIBUTORS

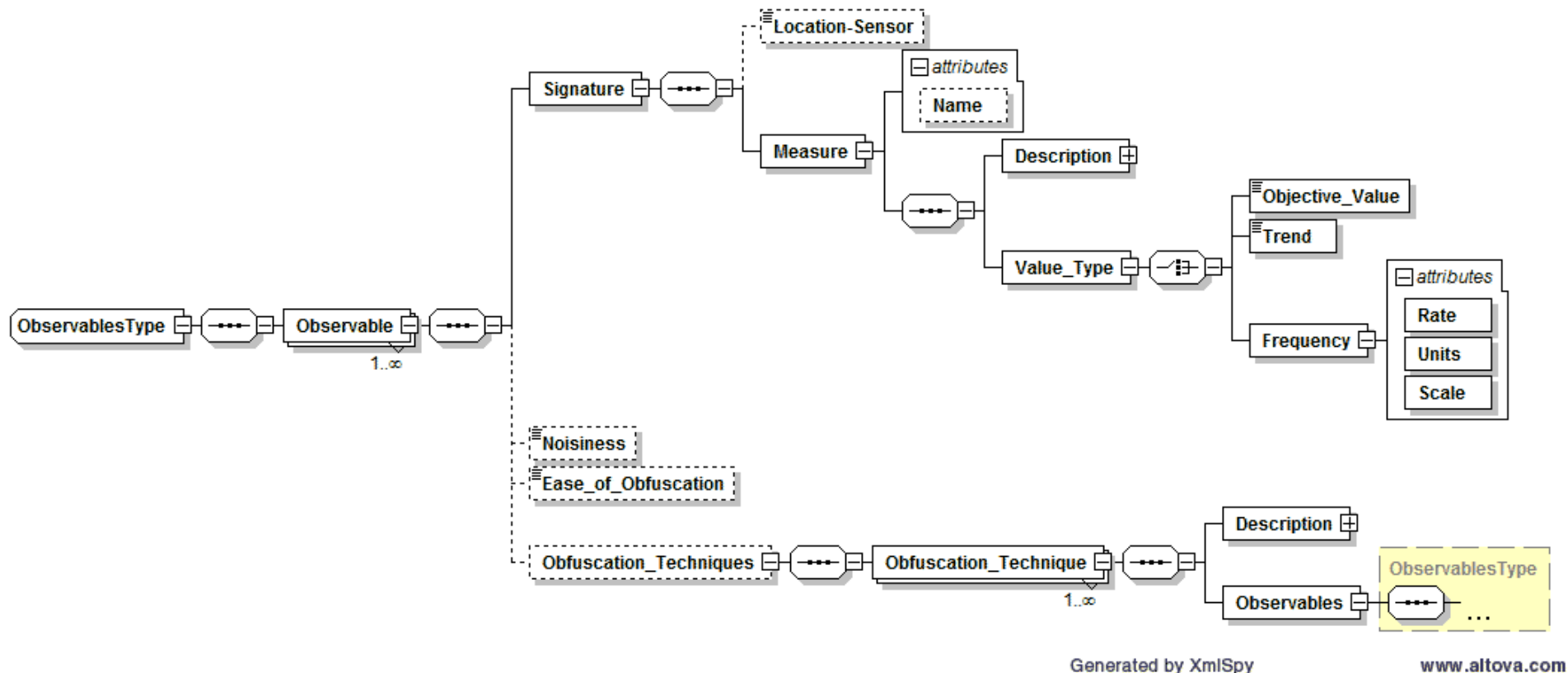
Gunter Blitz, SAP AG	Steve Lipner, Microsoft Corp.
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# CWE CAPEC

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# Bridging Secure Software Development with Secure Software Operations

“Observables” schema introduced in v1.4



- Can adorn various elements in the attack execution flow (e.g. Attack\_Step, Attack\_Step\_Techniques, Outcome, Security\_Control)
- Will likely be added also to Indicators-Warnings\_of\_Attack, Probing\_Techniques, Obfuscation\_Techniques, Solutions\_and\_Mitigations



# The Future of “Observables”

- **Significant synergy exists between CAPEC, MAEC & CEE in the need for this construct**
- **CAPEC, MAEC & CEE are collaborating together to define one common schema (it may get leveraged by other MSM efforts as well)**
- **It is possible that this commonality may end up just being the core of CEE and we will then simply import in that schema for leveraging**



# A Few Use Cases for “Observables” in Bridging Secure Development (SD) and Secure Operations (SO)

- SO: Correlate observed events (realtime or from incident management) to detect that attack is occurring
- SO: Correlate observed events (realtime or from incident management) to identify what type of attack is occurring
- SO: Utilize info in relevant CAPEC patterns to focus where else to look for other indicators of attack
- SO: Utilize info in relevant CAPEC patterns to focus where else to look to determine severity of breach
- SO: Utilize info in relevant CAPEC patterns to characterize the attacker (including maybe someday supporting attribution)
- SD: Utilize real-world operations events to identify new attack patterns
- SD: Utilize real-world operations events to prioritize relevant attack patterns based on reality of what is being used
- SD: Utilize real-world operations events to determine if mitigations are effective



# CAPEC Future Plans

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- V1.6

- At least 30 more patterns fleshed out from hooks & stubs to full
- Some network attack patterns with fleshed out attack surface info
- Initial set of supply chain and social engineering attack patterns
- Potentially refined “observables” schema

- Strategic focus for the near to mid-term will be on utilizing CAPEC as a bridge between secure development and secure operations

- Continue expanding and refining content

- Continue expanding outreach and supporting CAPEC use

- Establish initial compatibility program



# Questions?

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**Know Your Weaknesses**

<http://cwe.mitre.org>

**CWE**<sup>TM</sup>

**CAPEC**<sup>TM</sup>

<http://capec.mitre.org>

**Know Their Attacks**