Expecting Secure, High-Quality Software:

Mitigating Risks throughout the Lifecycle by Reducing Attack Vectors

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USAF LtCol (Retired)

10 Sep 2018

What is the Consortium for IT Software Quality?

Software Engineering Institute
Carnegie Mellon

OBJECT MANAGEMENT GROUP®

Co-founders

IT Executives → **CISQ** ← Technical Experts

OMG Special Interest Group

CISQ is chartered to define automatable measures of software size and quality that can be measured in the source code, and promote them to become Approved Specifications of the OMG®

Sponsors

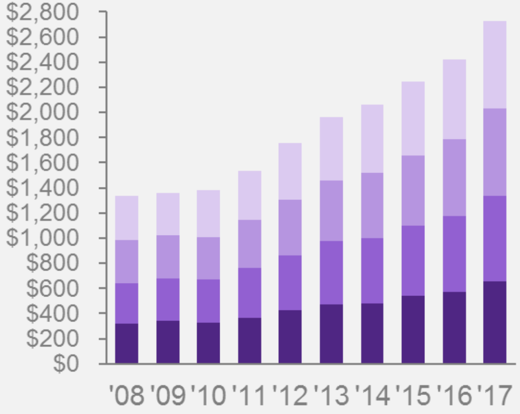
CAST — Achieve Insight. Deliver Excellence.
Synopsys®
Cognizant
SHPI — advanced technology • native know-how
Northrop Grumman
Tech Mahindra
CGI

Synopsys Today: From Silicon to Software

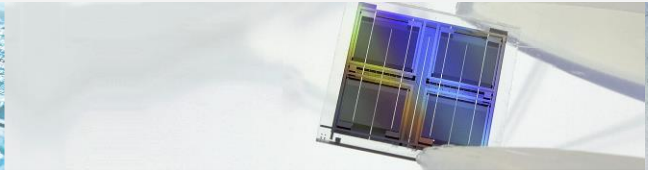
FY17 Revenue: ~$2.7B

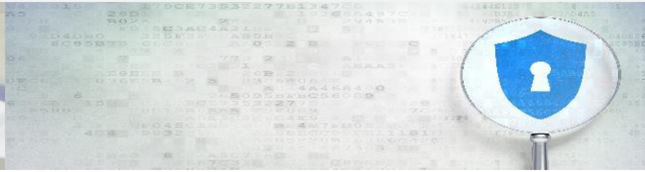
Employees: >11,600

Years: 30+



- **#1 EAD** electronic design automation tools & services
- **Broadest IP portfolio** and **#1** interface, analog, embedded memories & physical IP
- **'Leader'** in Gartner's Magic Quadrant for application security testing
- **'Engineer Driven Culture'** Over half our employees have advance degrees





Security and quality are in our DNA

SYNOPSYS®

Software Integrity Group (SIG)

codenomicon
Acquired 2015
Team and technology that found Heartbleed

BLACKDUCK
Acquired 2017
The authority on open source security and risk management

protecode

FORCHECK

goanna

codiscope

Cigital
Acquired 2016
400+ security experts
Full portfolio of managed and professional services

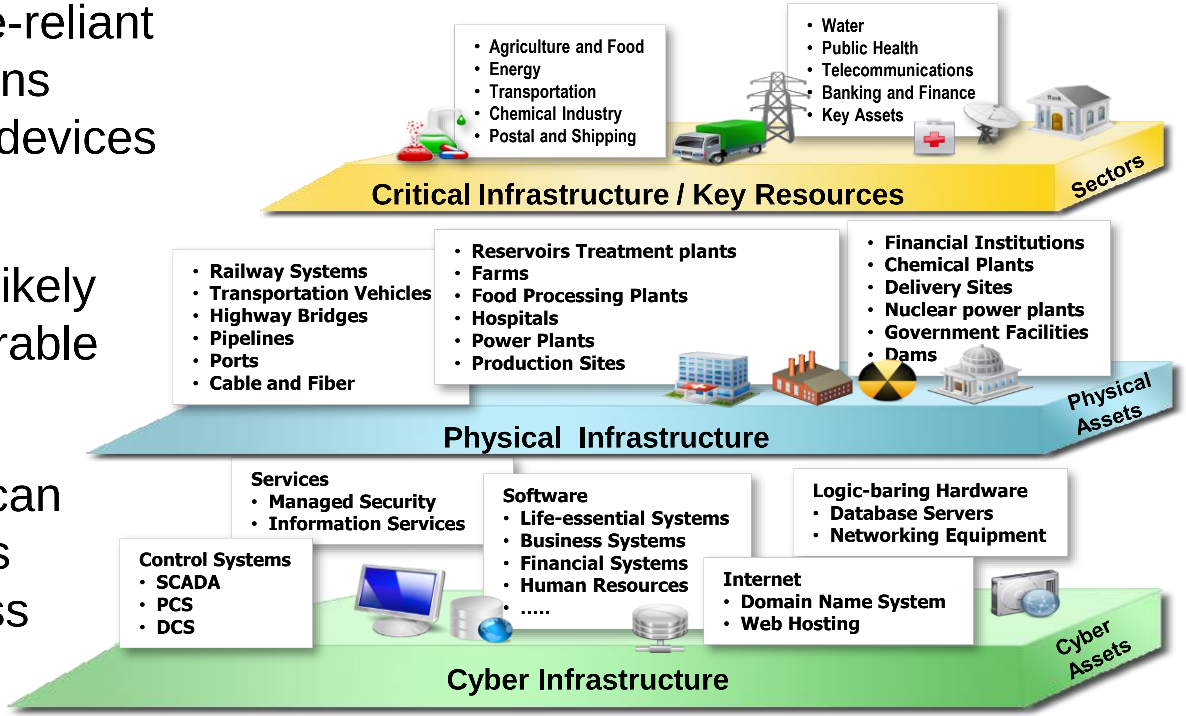
Seeker

kalistick

coverity™
Acquired 2014
The leading static analysis solution for security and quality

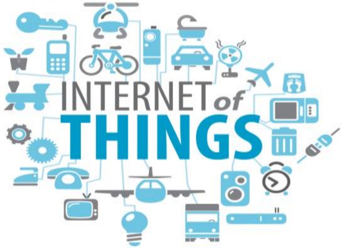
Gaining confidence in ICT/IoT software-based technologies

- Dependencies on software-reliant Information Communications Technology (ICT) and IoT devices are greater then ever
- Possibility of disruption is likely because software is vulnerable and exploitable
- Loss of confidence alone can lead to stakeholder actions that disrupt critical business activities



Cyber Infrastructure is enabled and controlled by software

An ever-more connected world . . .



Goods & Services

- Track materials
- Speed distribution
- Product feedback

People

- Wellness monitoring
- Medical case management
- Social needs

Communities

- Traffic status
- Pollution alerts
- Infrastructure checks

Environment

- Pollution checks
- Resource status
- Water monitoring

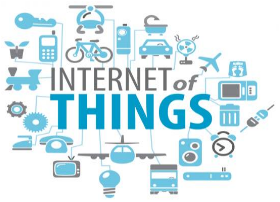
Homes

- Utilities control
- Security monitoring
- Structure integrity

Organizations expanding their IoT efforts need comprehensive software security initiatives to address weaknesses resulting from technological vulnerabilities, a lack of ‘cyber hygiene’ and caution among those who develop and use IoT devices.

Cyber Risks and Consequences in IoT Solutions

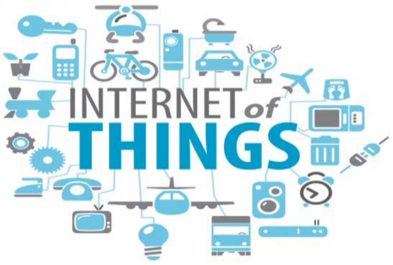
Creating More Attack Vectors



- **Edge Devices (including Applications, Sensors, Actuators, Gateways & Aggregation)**
  - –Device Impersonation, Counterfeiting & Hacking
  - –Snooping, Tampering, Disruption, Damage
- **IoT Platform (Data Ingestion/Analytics, Policy/Orchestration, Device/Platform Mgmt)**
  - –Platform Hacking
  - –Data Snooping & Tampering
  - –Sabotaging Automation & Devices
- **Enterprise (Business/Mission Applications, Business Processes, etc)**
  - –Business/Mission Disruption
  - –Espionage & Fraud / Financial Waste

If you cannot afford to protect IoT; then you cannot afford to connect it -
Cost of recovering from exploitation far exceeds costs to protect IoT

Growing Concern with Internet of Things (IoT)

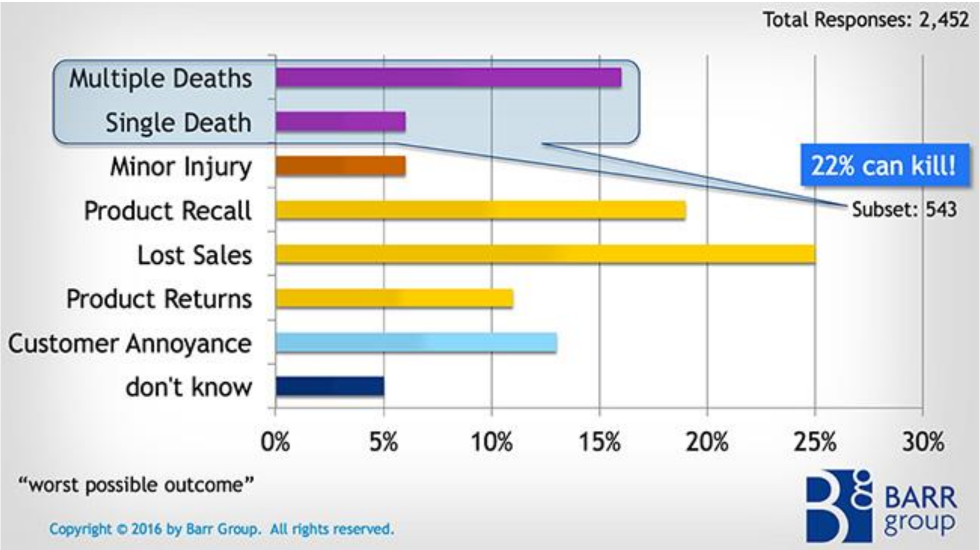


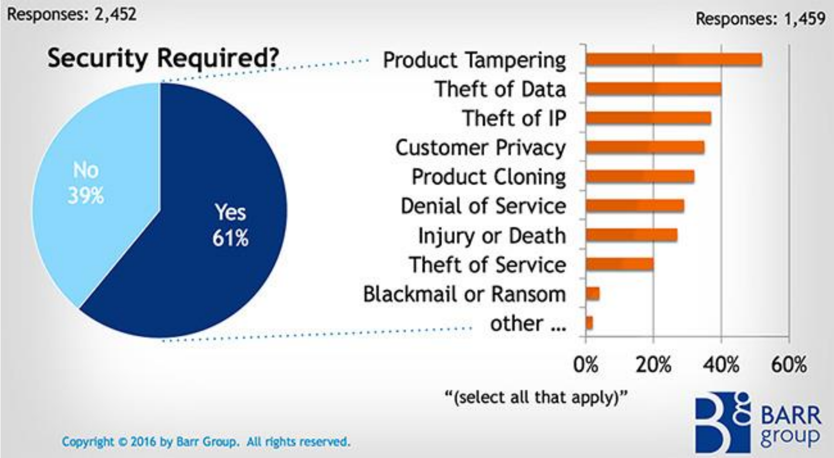
- Lax security without liability for the growing number of IoT embedded devices in appliances, industrial applications, vehicles, smart homes, smart cities, healthcare, medical devices, etc.
  - Sloppy manufacturing ‘hygiene’ is compromising privacy, safety and security – incurring risks for faster time to market
  - IoT risks provide more source vectors for financial exploitation
  - IoT risks include virtual harm to physical harm
    - Cyber exploitation with physical consequences;
    - Increased risk of bodily harm from hacked devices
- Growing dependence on external third-party supplier put users and enterprises more at risk due to exploitable software

Safety/Security Risks with IOT embedded systems

Engineering Community concerns:

- Poorly designed embedded devices can kill;
- Security is not taken seriously enough;
- Proactive techniques for increasing safety and security are used less often than they should be.





Barr Group: "Industry is not taking safety & security seriously enough"

Based on results of survey of more than 2400 engineers worldwide to better understand the state of safety- and security-aware embedded systems design around the world (Feb 2016).

Shifting Business Concerns: Increased Software Liability

1980's — 1990's — 2000's — 2010's

Quality

Quality / Security

Quality / Security / Safety & Privacy

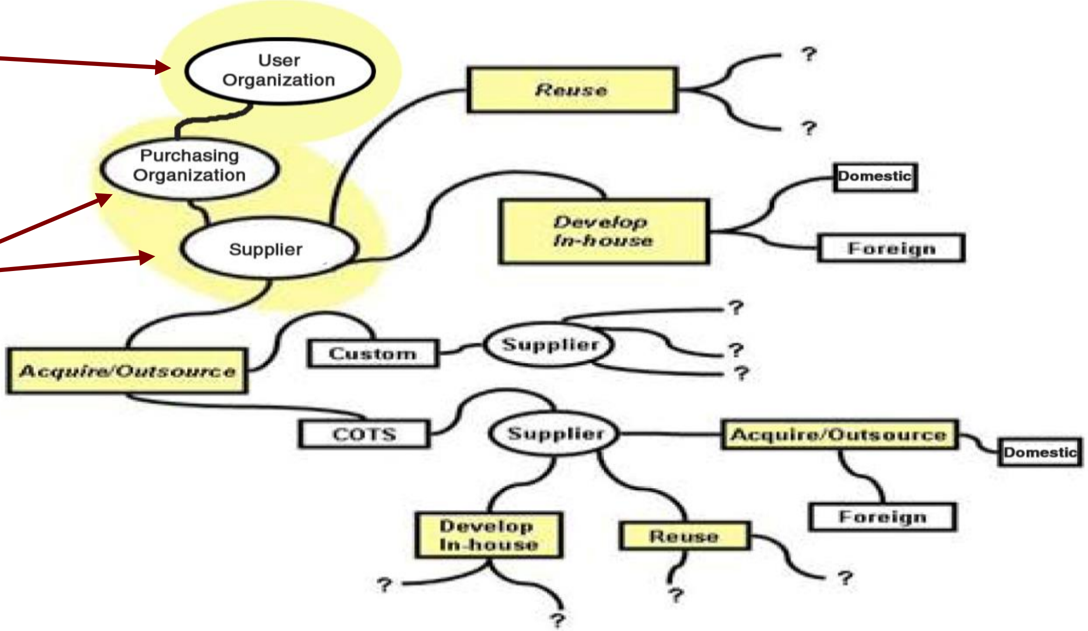
Financial Liability

Software Supply Chain Management

Enabling Enterprise Control of Risks Attributable to Exploitable Software

Risk Management (Enterprise ⟺ Project):
Shared Processes & Practices ⟺ Different Focuses

- Enterprise-Level:
  - Regulatory compliance
  - Changing threat environment
  - Business Case
- Program/Project-Level:
  - Cost
  - Schedule
  - Performance

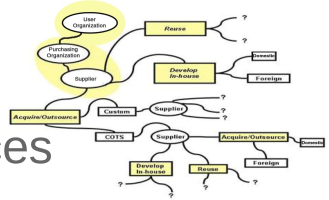


Who makes risk decisions?
Who determines 'fitness for use' for 'technically acceptable' criteria?
Who "owns" residual risk from tainted/counterfeit products?

* "Tainted" products are those that are corrupted with malware, or exploitable weaknesses & vulnerabilities

IoT supply chain risk management

Mitigating 3rd-party risks attributable to exploitable software in IoT devices



Increased risk from supply chain due to:

Increasing dependence on globally sourced devices

- Varying levels of development/outsourcing controls
- Lack of transparency in process chain of custody
- Varying levels of acquisition ‘due-diligence”

Residual risk from tainted components

- Tainted products with malware, exploitable weaknesses (CWEs) and vulnerabilities (CVEs)
- Defective and unauthentic/counterfeit products

Growing technological sophistication among adversaries

- Internet enables adversaries to probe, penetrate, & attack remotely
- Supply chain attacks can exploit products and processes

Software in the supply chain is often the vector of attack

Majority of Breaches Attributable to Exploitable Software

Data Breaches make headlines – the cause of them rarely do

- ✓ **84% of breaches originate at the application layer** (CMU SEI, 2018)
- ✓ **84% of all cyber-attacks happen on the application layer** (SAP)
- ✓ **Over 70 % of security breaches happen at the Application** (Gartner)
- ✓ 92% of vulnerabilities are in application layer (NIST)
- ✓ **Up to 80% of of Data Breaches originate in the Supply Chain** (SANs Institute)
- ✓ More than 80% of Enterprises depend on third-party code (Gartner)
- ✓ **90% of a typical application is comprised of third-party / OSS components** (SANS)
- ✓ Most developers lack sufficient security training (Gartner)
- ✓ **Web Application Attacks are the #1 source of data breaches** (Verizon DBIR)

Data breaches exploit vulnerabilities and weaknesses in applications -- root causes in unsecure software –- this is a supply chain issue

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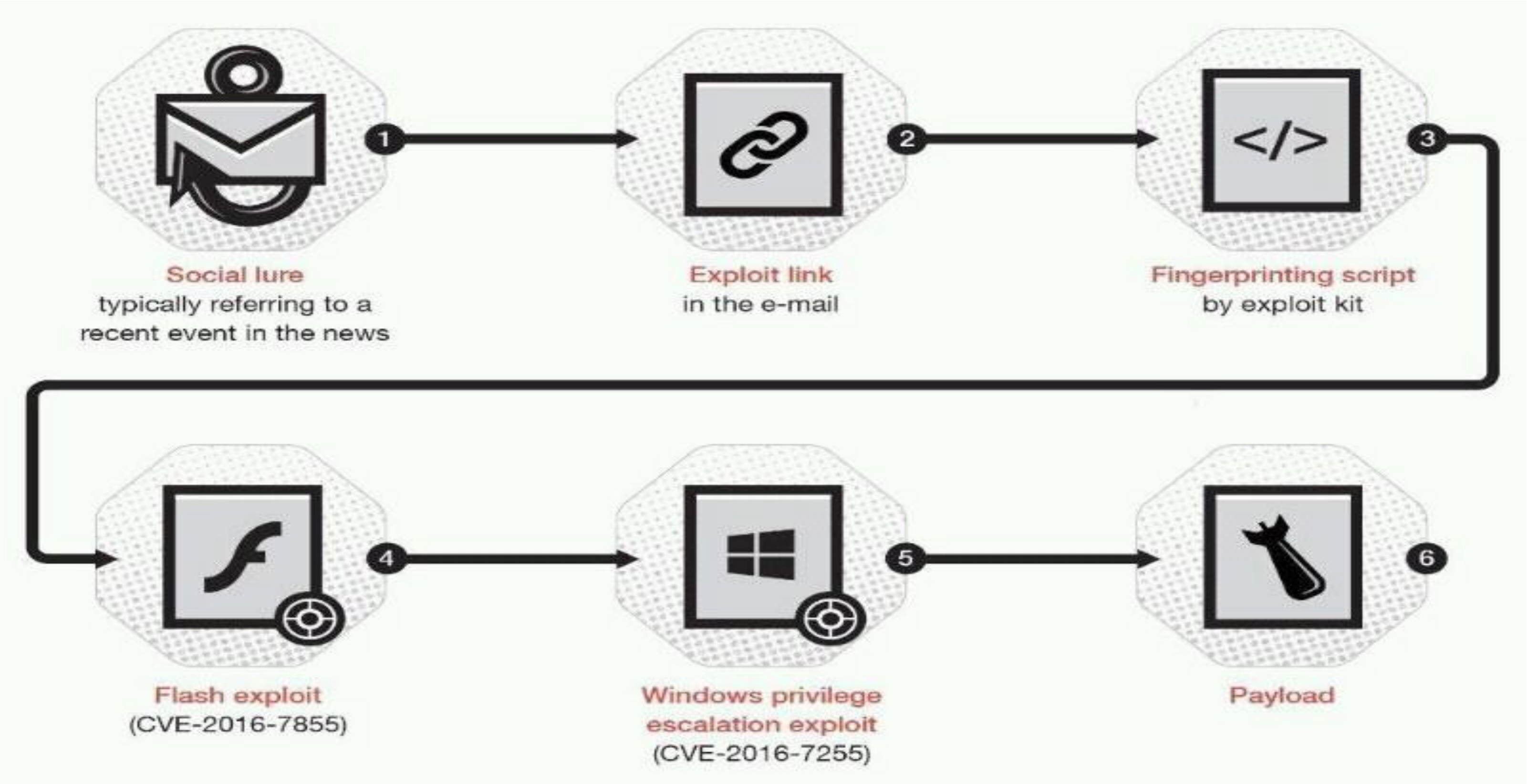
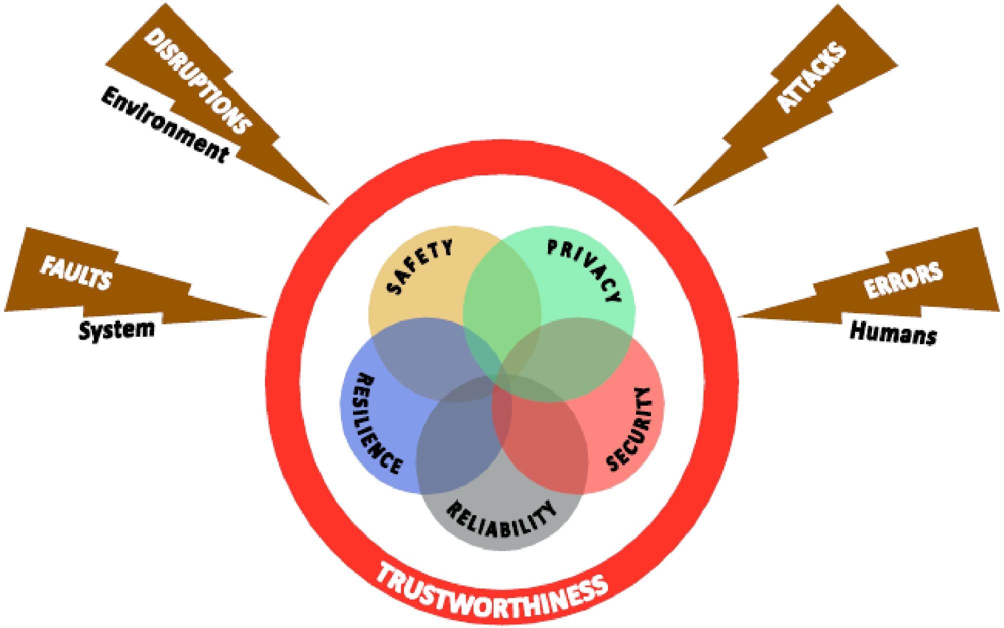
Unmitigated Software Vulnerabilities and Weaknesses:
Example of root causes/attack vectors for exploitation



Trustworthiness of an Industrial IoT System

Trustworthiness *(in any IIoT device)* is degree of confidence one has that the system performs as expected in respect:

- to *all* the key system characteristics *(associated with safety, resilience, reliability, security, and privacy)*
- in the face of environmental disruptions, human errors, system faults and attacks.



Source Definition: Industrial Internet Consortium (IIC) Industrial Internet of Things (IIoT) Security Framework

Enterprises Have Used Reactive Technologies to Defend…

They are good; designed for known threats. What about broader risks to enterprises and users?

Enterprises cannot stop the threats; yet can control their attack vectors/surfaces

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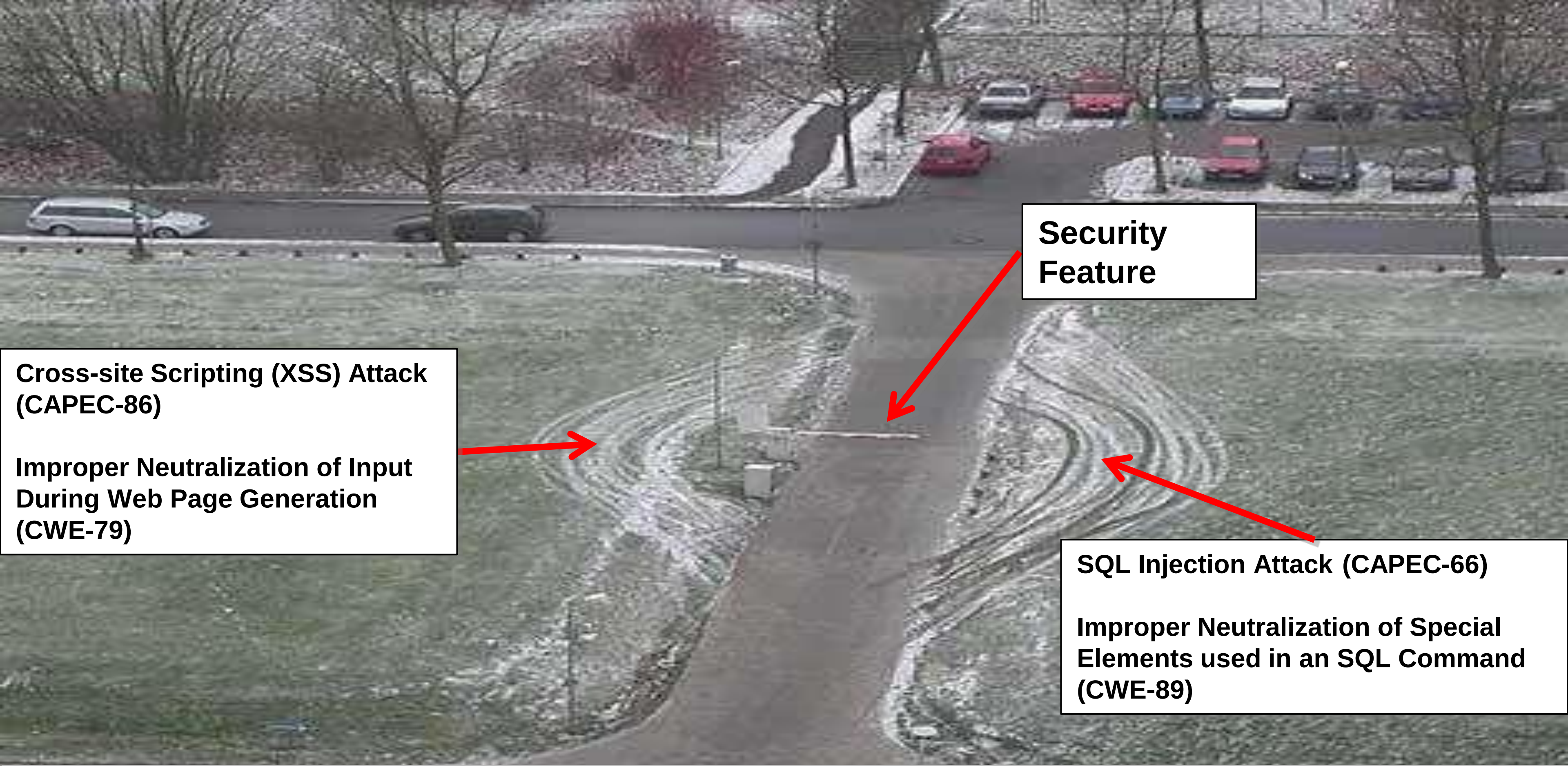


Exploitable Software Weaknesses (CWEs) are exploit targets/vectors for future Zero-Day Attacks catalogued as Vulnerabilities (CVEs)

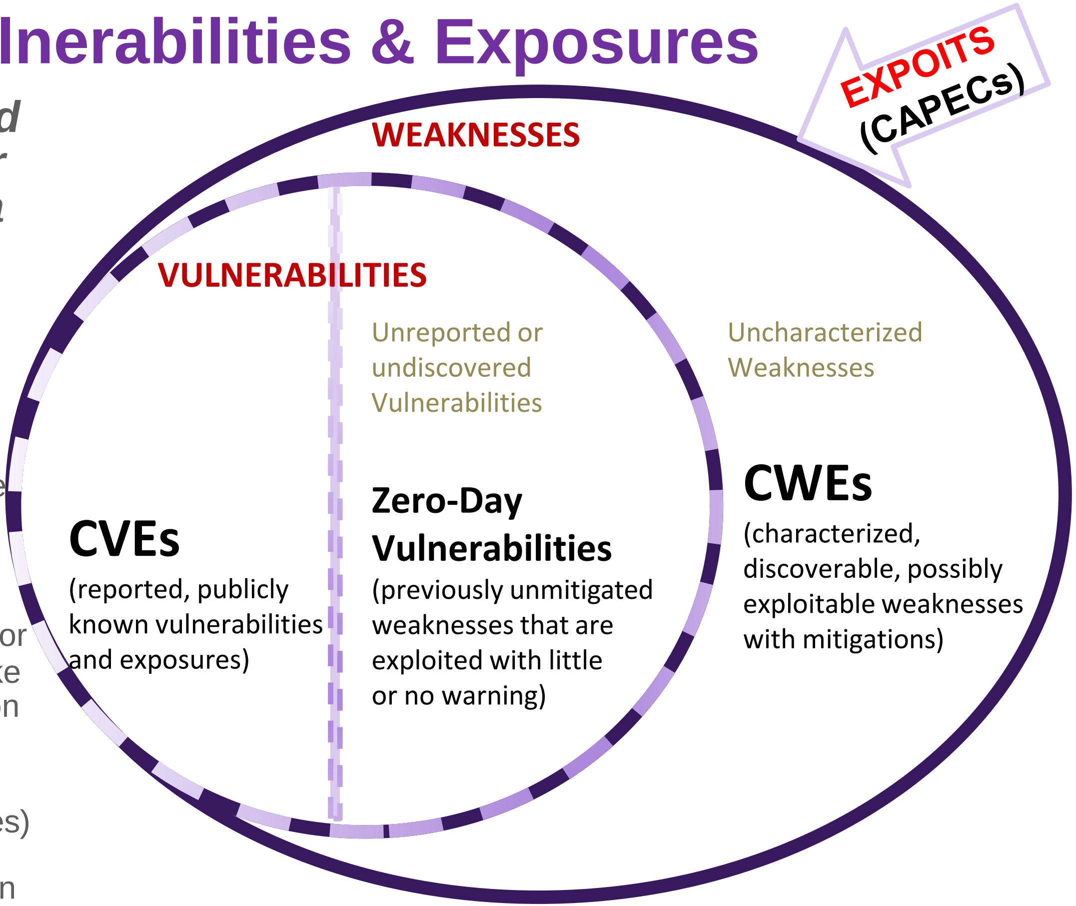
Common Vulnerabilities and Exposures

The Standard for Information Security Vulnerability Names

300+ PRODUCTS AND SERVICES FROM 152 ORGANIZATIONS IN 25 COUNTRIES

Exploits, Weaknesses, Vulnerabilities & Exposures

- ***The existence of an exploit designed to take advantage of a weakness (or multiple weaknesses) and achieve a negative technical impact is what makes a weakness a vulnerability.***
- **Weakness:** mistake or flaw condition in ICT/IoT architecture, design, code, or process that, if left unaddressed, could under the proper conditions contribute to a cyber-enabled capability being vulnerable to exploitation; represents potential source vectors for zero-day exploits -- Common Weakness Enumeration (CWE) https://cwe.mitre.org/
- **Vulnerability:** mistake in software that can be directly used by a hacker to gain access to a system or network; **Exposure:** configuration issue of a mistake in logic that allows unauthorized access or exploitation – Common Vulnerability and Exposure (CVE) https://cve.mitre.org/
- **Exploit:** action that takes advantage of weakness(es) to achieve a negative technical impact -- attack approaches from the set of known exploits are used in the Common Attack Pattern Enumeration and Classification (CAPEC) https://capec.mitre.org



Part of the ITU-T CYBEX 1500 series (CVE ITU-T X.1520, CWE ITU-T X.1524, CAPEC ITU-T X.1544) & USG SCAP

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CVE & CWE Can Be Used to Assess Software Maturity

- Are the commercial and open source applications being used as part of the system, the development environment, the test environment, and the maintenance environment to detect CWEs/CVEs and patched for known CVEs?
- Are any components/libraries incorporated in the system that have CVEs?
- Have pen testing tools/teams found any CVEs?
- Does the project team monitor for Advisories?
- Do projects utilize CVSS/CWSS scores to prioritize remediation efforts?
- Is the use of CWE and CVE Identifiers and public advisories a consideration when selecting commercial and open source applications?

CVE & CWE are some of the means for sharing information about risk exposures in software supply chain management

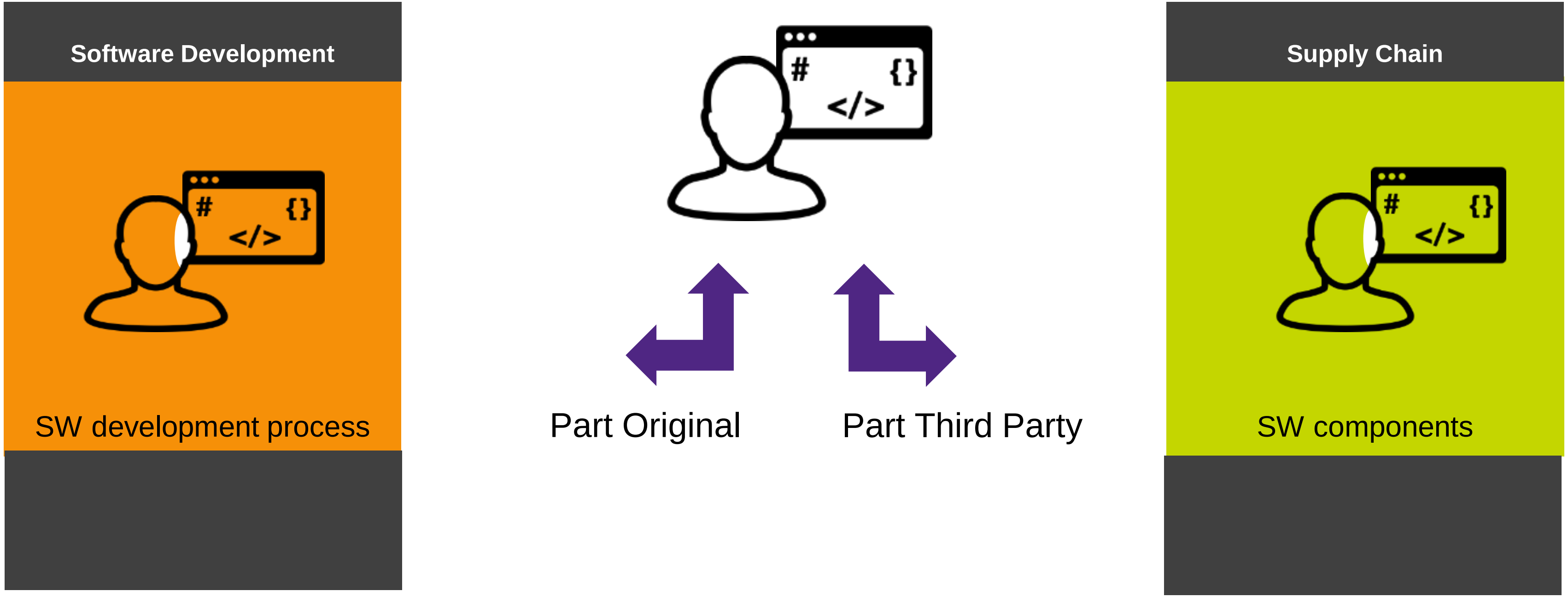
Products on "Whitelisted" Approved Products List or "Assessed & Cleared" Products List should be Tested for…

- **Exploitable Weaknesses (CWEs, ITU-T X.1524)**
  - If suppliers do not mitigate exploitable weaknesses or flaws in products (which are difficult for users to mitigate), then those weaknesses represent vectors of future of exploitation and 'zero day' vulnerabilities.
- **Known Vulnerabilities (CVEs, ITU-T X.1520)**
  - If suppliers cannot mitigate known vulnerabilities prior to delivery and use, then what level of confidence can anyone have that patching and reconfiguring will be sufficient or timely to mitigate exploitation?
- **Malware (MAEC, ITU-T X.1546)**
  - If suppliers do not check that the software they deliver does not have malware (typically signature-based), then users and using enterprises are at risk of whitelisting the malware.

Software development is more challenging every day

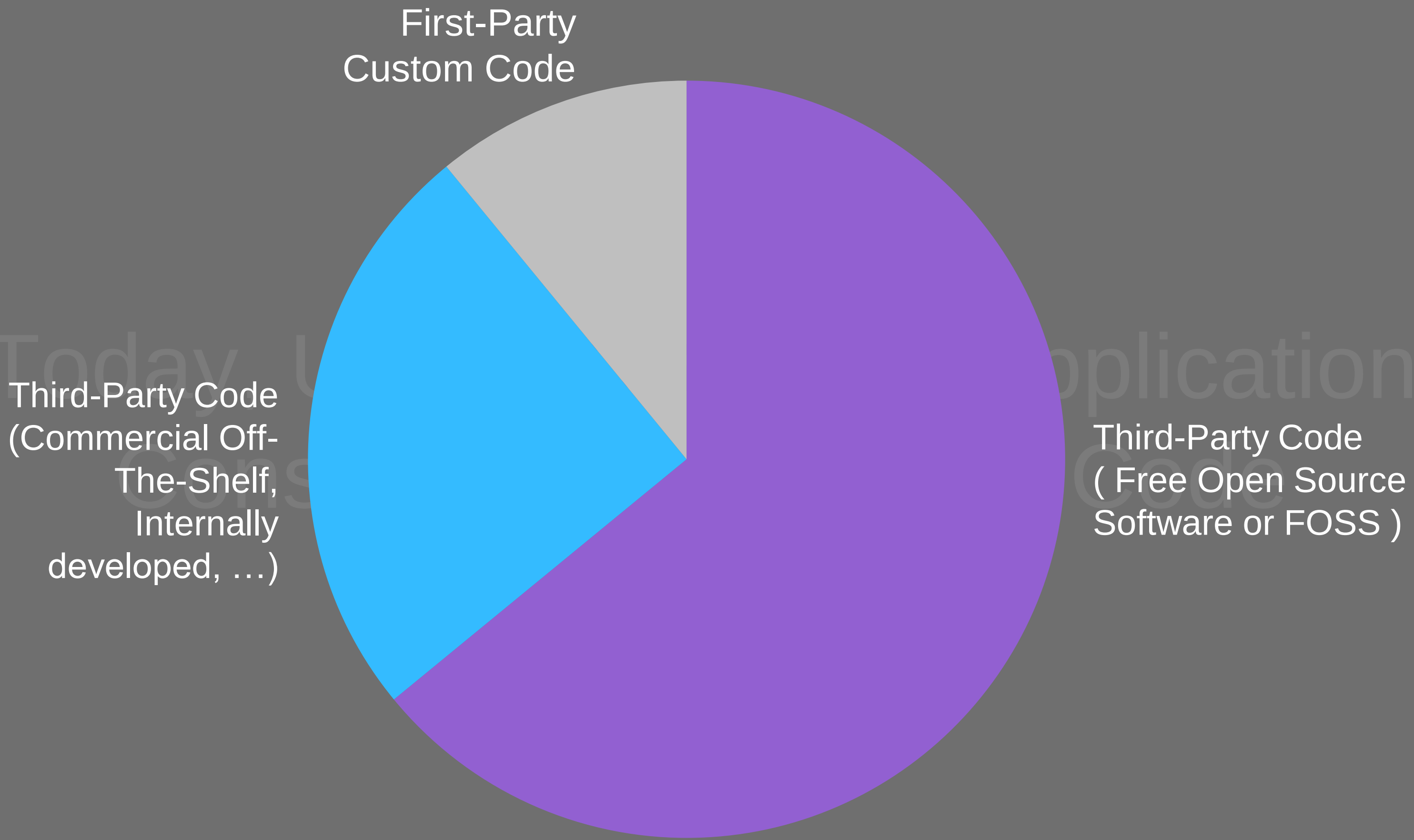
New Attack Vectors	Shorter Product Cycles	Increasing Complexity
		
Embedded/IoT Cloud Mobile Open Source	Agile CI/CD DevOps Containers	Languages Tools Dependencies Supply Chain

Software Today Is Assembled



Software supply chain includes development and third-party components

Today, Up to 90% of an Application Consists of Third-Party Code


First-Party Custom Code
Third-Party Code (Commercial Off-The-Shelf, Internally developed, …)
Third-Party Code (Free Open Source Software or FOSS)

Do you trust what's in your Third-Party Code?

Software Testing

Enabling Insight into Risks Attributable to Exploitable Software

Software Supply Chain Risk Management:

Testing Software & Enabling Cybersecurity Assurance for Network-Connectable Devices

Software is buggy	Input processing can be exploited	Hackers use binary analysis & fuzzing techniques to find vulnerabilities
How many exploitable weaknesses and vulnerabilities are in your systems and devices?	Any software processing input can be attacked: **-** network interfaces, - device drivers, - user interfaces, etc..	These are used to exploit or launch attacks These can also be discovered & mitigated by suppliers; These should be used in test criteria for acceptance testing

Different techniques address different risks

Static Analysis

- Analyzes source code
- Finds common security weaknesses (CWEs):
  - SQL injection
  - Cross-site scripting
  - Buffer overflows, etc.

Best for proprietary code

Coverity

Software Composition Analysis

- Scans for open source
- Finds open source vulnerabilities (CVEs):
  - Detects known vulns
  - Works through full SDLC
  - Monitors for new vulns

Best for open source

Black Duck

Dynamic Analysis

- Tests running apps
- Finds vulnerable app behavior:
  - Misconfigurations
  - Authentication issues
  - Business logic flaws

Best for running apps

Defensics & Seeker

Some Prioritized Lists To Consider

Top 10

- OWASP Top 10 Vulnerabilities – A list of Most Critical Web Application Security Risks compiled by OWASP (https://www.owasp.org/index.php/Category:OWASP_Top_Ten_Project) – includes CVEs & CWEs
- SANS CWE Top 25 – A list of top 25 most commonly encountered Cyber Weakness Enumerators (CWEs), found in (https://www.sans.org/top25-software-errors/)
- Object Management Group (OMG) Automated Source Code Security Measure (ASCSM)TM v1.0, 2016 at http://it-cisq.org/wp-content/uploads/2016/01/Automated-Source-Code-Security-Measure-OMG-Formal-January-2016.pdf -- A list of top-22 code-level CWEs
- Verizon Report Top 10 CVEs – List of most commonly encountered Common Vulnerabilities & Exposures (CVEs) used in exploits (http://news.verizonenterprise.com/2015/04/2015-data-breach-report-info/)

Insecure Interaction Between Components

These weaknesses are related to insecure ways in which data is sent and received between separate components, modules, programs, processes, threads, or systems.

CWE ID	Name
CWE-89	Improper Neutralization of Special Elements used in an SQL Command ('SQL Injection')
CWE-78	Improper Neutralization of Special Elements used in an OS Command ('OS Command Injection')
CWE-79	Improper Neutralization of Input During Web Page Generation ('Cross-site Scripting')
CWE-434	Unrestricted Upload of File with Dangerous Type
CWE-352	Cross-Site Request Forgery (CSRF)
CWE-601	URL Redirection to Untrusted Site ('Open Redirect')

Risky Resource Management

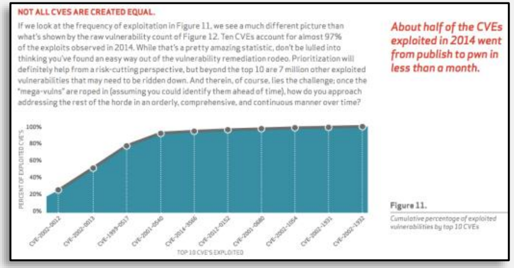
The weaknesses in this category are related to ways in which software does not properly manage the creation, usage, transfer, or destruction of important system resources.

CWE ID	Name
CWE-120	Buffer Copy without Checking Size of Input ('Classic Buffer Overflow')
CWE-22	Improper Limitation of a Pathname to a Restricted Directory ('Path Traversal')
CWE-494	Download of Code Without Integrity Check
CWE-829	Inclusion of Functionality from Untrusted Control Sphere
CWE-676	Use of Potentially Dangerous Function
CWE-131	Incorrect Calculation of Buffer Size
CWE-134	Uncontrolled Format String
CWE-190	Integer Overflow or Wraparound

Porous Defenses

The weaknesses in this category are related to defensive techniques that are often misused, abused, or just plain ignored.

CWE ID	Name
CWE-306	Missing Authentication for Critical Function
CWE-862	Missing Authorization
CWE-798	Use of Hard-coded Credentials
CWE-311	Missing Encryption of Sensitive Data
CWE-807	Reliance on Untrusted Inputs in a Security Decision
CWE-250	Execution with Unnecessary Privileges
CWE-863	Incorrect Authorization
CWE-732	Incorrect Permission Assignment for Critical Resource
CWE-327	Use of a Broken or Risky Cryptographic Algorithm
CWE-307	Improper Restriction of Excessive Authentication Attempts
CWE-759	Use of a One-Way Hash without a Salt



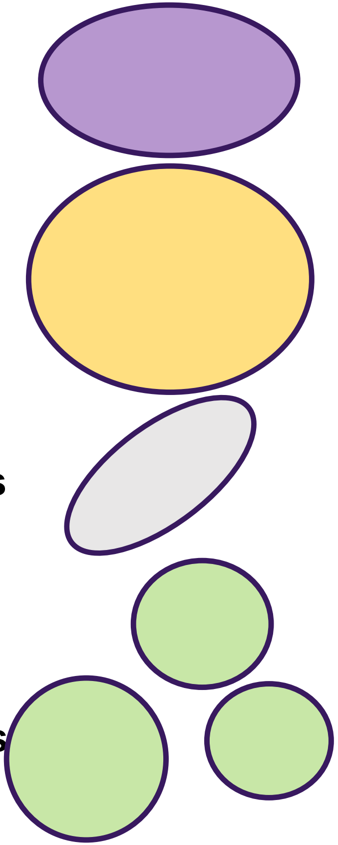
Utilizing a Priority List of Weaknesses

Code Review

Static Analysis Tool A

Static Analysis Tool B

Pen Testing Services



CWEs a capability *claims* to cover

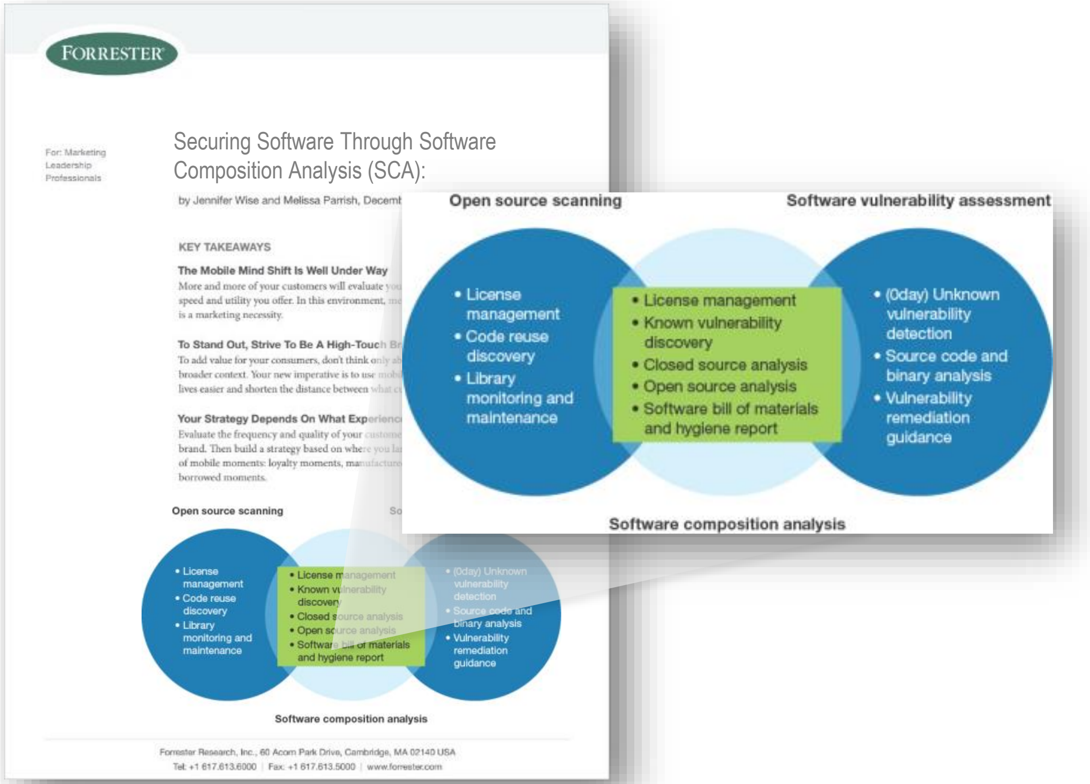
Which static analysis tools and Pen Testing services find the CWEs I care about?

Slide provided by Bob Martin, MITRE

Software Composition Analysis (SCA) is needed:

Components of Software Composition Analysis (SCA) solution:

- Vulnerability assessment and tracking
- [FOSS] license management and export compliance
- Software Bill of Materials (BOM) identification and management



SCA Provides Ingredients List (Software Bill of Materials):

Resource for determining risk

Your application

=

Proprietary Code

+

Open Source Components

+

Application Behavior & Config

Application Facts

Code Label

Protex

Code Base: 20.452GB

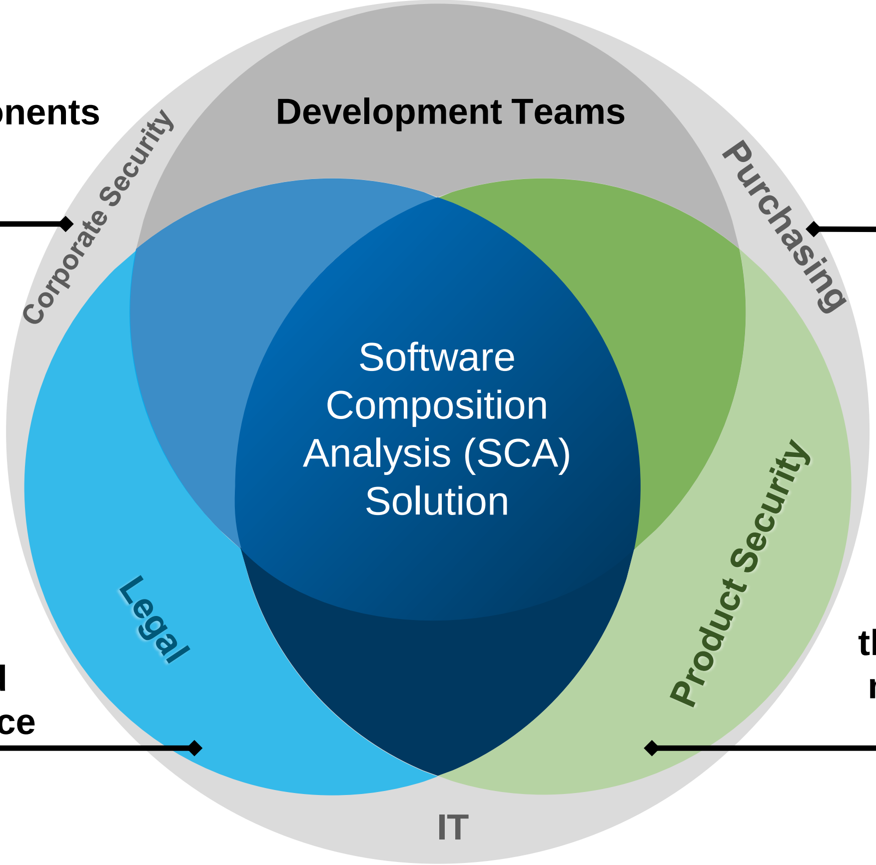
	% Content
Total Open Source: 4.947GB	
Reciprocal as Components: 3.915GB	24.19%
Reciprocal as Files: 0.252GB	19.14%
Permissive: 0.003GB	1.23%
Owned: 0MB	0%
Total Proprietary: 11.335GB	55.42%
Licensed 3rd Party: 0.354GB	1.73%
Owned: 10.981GB	53.69%
Total Unknown: 0MB	0%

Code Genetics

Comprehensive Software Composition Analysis (SCA)

Scan and Report Components with Known Security Vulnerabilities

Detect and manage 3rd party and open source components or portions thereof

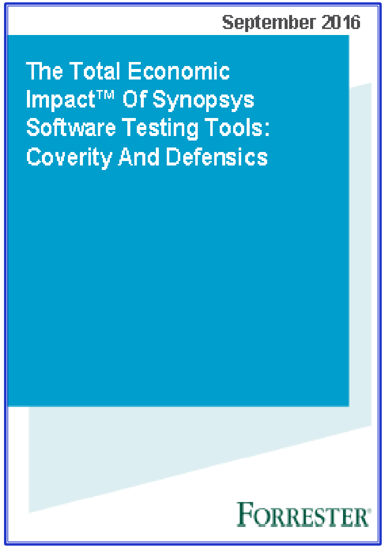


Ensure Licensing, IP, and Export Control Compliance

The versatility and breadth of this solution makes it viable for many use cases and appealing to many personas

Total Economic Impact of Synopsys Software Testing Tools

Forrester Case Study – Useful Framework



Using Coverity and Defensics in the development lifecycle…

- **Improved product quality and security**
  - Avoided remediation expenses in 8 code bases of 1.5M LoC each; saving $3.86M (NPV)
  - Lowered defect density within its code base…
    prevented future costs of allowing error-prone code to be reused.
- **Reduced time to market**
  - Using fuzz testing and static analysis, reduced product release cycle from 12 to 8 months; enabling company to redirect resources toward other productive activities.
  - Decreased time to detect and remediate defects/vulnerabilities;
- **Prevented high-profile breaches**
  - Lowered future risk exposure attributable to exploitable software
- **Mitigated costly post-deployment malfunctions**
  - Required 2 times fewer labor hours than in post-release phase

Numerical Data

ROI: **136%** **//** Total NPV: **$5.46m**
Cost to find & fix bugs: ↓**2x-10x**
Time to release new products: ↓**4mo**

Access full report at http://software.synopsys.com/register-for-coveritydefensicsTEIstudy.html

The Synopsys Software Integrity Toolbelt

Everything you need to build security and quality into your SDLC

SYNOPSYS®

STAGE 1
PLAN

RECOMMENDED TOOLS:

BSIMM: What is the current state of your software security?

MAP: How can you improve your software security?

Test Optimization: Have tests been prioritized and created?

STAGE 2
DESIGN

RECOMMENDED TOOLS:

Architecture Risk Analysis: Have secure design best practices been implemented?

Threat Modeling: How can an attacker exploit your design?

Security Control Design Analysis: Are there any missing or weak security controls?

STAGE 3
IMPLEMENT

RECOMMENDED TOOLS:

SAST: Are you finding and fixing bugs while you code?

Software Composition Analysis (SCA): Are there any bugs in the OSS or third-party software?

IAST: Are you able to identify real business threats?

Fuzz Test: Can each code component properly handle malformed inputs and unexpected loads?

STAGE 4
VERIFY

RECOMMENDED TOOLS:

SAST / SCA: Are there any remaining bugs in custom code or OSS/third-party software?

IAST: Can you automate IAST testing into your CI/CD processes?

DAST: Are you able to dynamically test your app before release?

Fuzz Test: Is the integrated code able to properly handle malformed inputs?

Pen Test: Can you manually hack your app before it goes live?

STAGE 5
RELEASE

RECOMMENDED TOOLS:

DAST: Are new bugs uncovered when the app is running?

Network Pen Test: Is the network configuration secure?

Pen Test: What impact could an attacker have?

STAGE 6
RESPOND

RECOMMENDED TOOLS:

Insider Threat Detection: How easily can you be breached?

Red Teaming: Are you set to prevent and respond to incidents?

Threat Intelligence: Is your organization monitoring for known breaches?

Synopsys Software Security and Quality

Portfolio

Integrated Tools

- **Coverity** – Static Analysis
- **Black Duck** – Software Composition Analysis
- **Seeker & Defensics** – Dynamic Analysis

Managed Services

- Static Application Security Testing
- Mobile Application Security Testing
- Penetration Testing
- Dynamic Application Security Testing

Professional Services

- Architecture and Design
- Security Training
- DevSecOps Integration
- Cloud Security
- Industry Solutions

Strategy & Planning

- Building Security in Maturity Model (BSIMM)
- Maturity Action Plan (MAP)

Software supply chain risk management

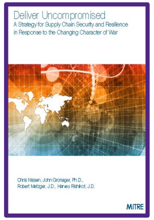
Procurement requirements, independent testing and certification

Deliver Uncompromised: A Strategy for Supply Chain Security and Resilience in Response to the Changing Character of War

US Department of Defense and Intelligence Community's focus to "Deliver Uncompromised" adds Security of products and services to existing contract evaluation criteria of Cost, Schedule and Performance.

Its roots in the MITRE report "Deliver Uncompromised: A Strategy for Supply Chain Security and Resilience in Response to the Changing Character of War" are driving changes in the law, as well as acquisition and procurement policies and practices.

Deliver Uncompromised: A Strategy for Supply Chain Security and Resilience in Response to the Changing Character of War



- “Software assurance needs to be made a priority for all phases of system acquisition and sustainment. DoD needs to work closely with technical community industrial partners to demonstrate and deploy new methods and measures to identify and respond to software vulnerabilities. Such initiatives acquire new urgency as more and more systems become interdependent and reliant upon the growing instrumentalities of the Internet of Things (IoT).”
- “Address the full span of software vulnerability through measures in acquisition and operations through full life cycle continuous security and risk reduction practices from concept through retirement. Determine where and for what programs or missions it is recommended or necessary to require submission of a Software Bill of Materials (SBOM) and require a documented Secure Software Design Life Cycle (SSDL).”
- Each Service component in both acquisition and sustainment should look for and coordinate information sharing among themselves and with designated software vulnerability information sharing mechanisms such as Common Vulnerabilities and Exposures (CVE), Information Sharing and Analysis Organizations (ISAOs), United States Computer Emergency Readiness Team (US-CERT), National Telecommunications and Information Administration (NTIA), and Department of Justice (DOJ).

Software Supply Chain Risk Management:

Proactive Control with Procurement Language for Supply Chain Cyber Assurance

Product Development Specification and Policy

Security Program

System Protection and Access Control

Product Testing and Verification

Deployment and Maintenance

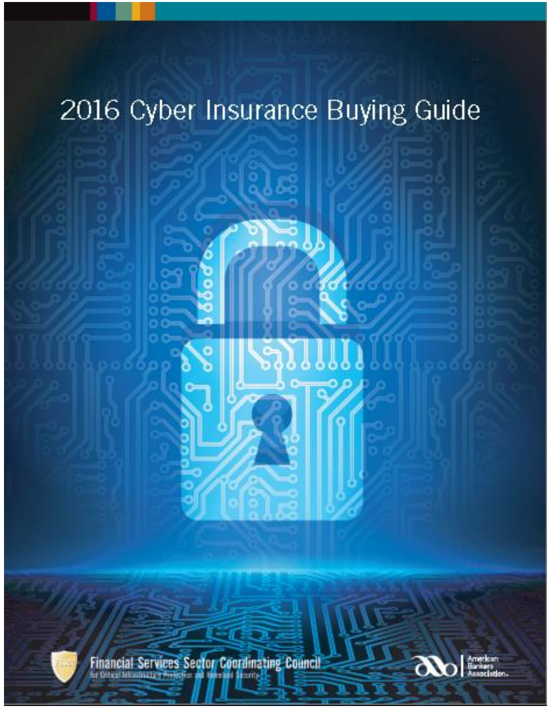
SYNOPSYS®

Procurement Language for Supply Chain Cyber Assurance

Exemplar
(freely available for download; used by other organizations)

https://www.synopsys.com/software-integrity/resources/white-papers/procurement-language-risk.html

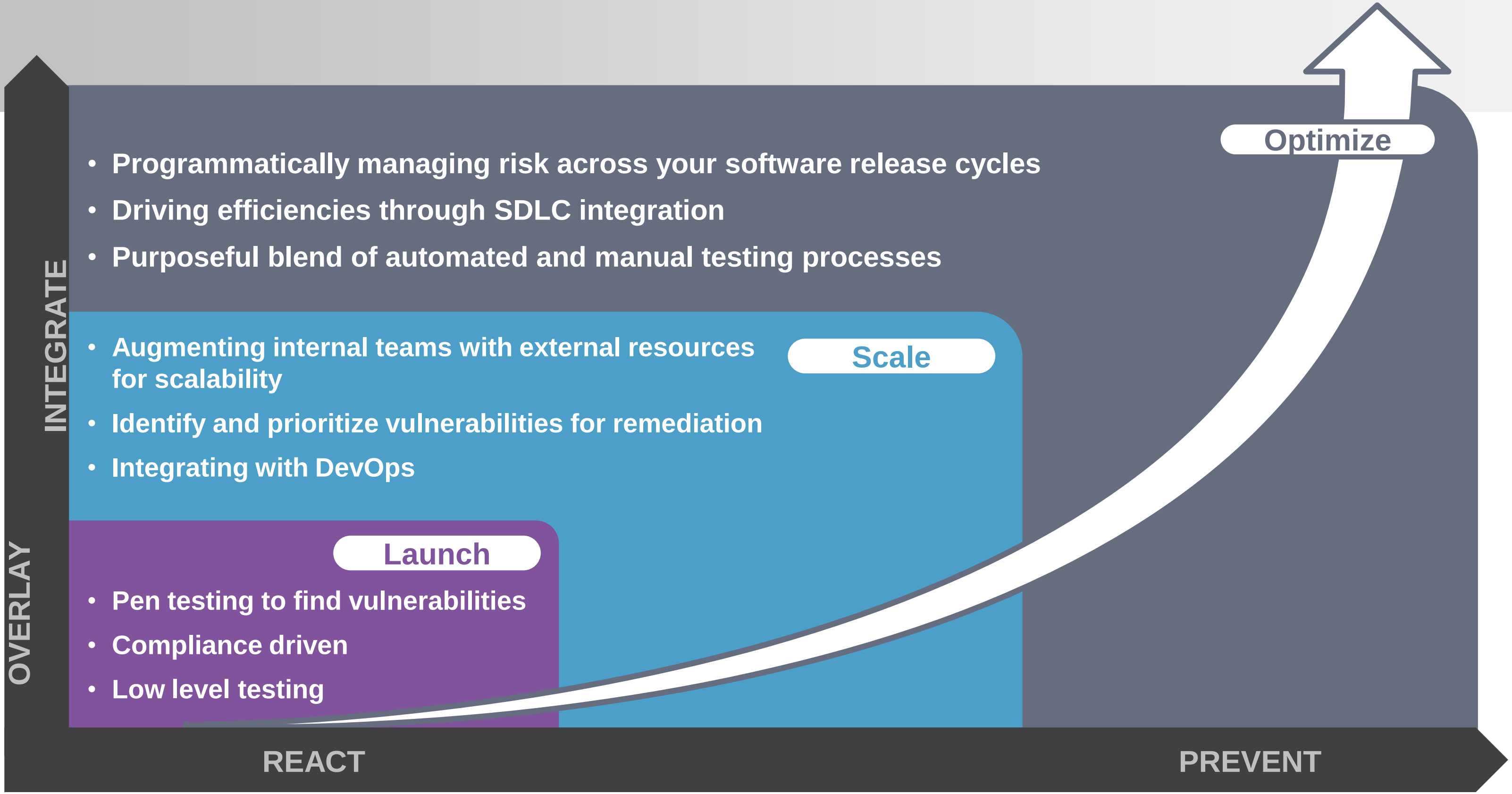
Supply Chain Cyber Assurance – Procurement Requirements



Source: Financial Services Sector Coordinating Council for Critical Infrastructure Protection and Homeland Security

- Product Development Specification and Policy
- Security Program
- System Protection and Access Control
- Product Testing and Verification
  - Communication Robustness Testing
  - Software Composition Analysis
  - Static Source Code Analysis
  - Dynamic Runtime Analysis
  - Known Malware Analysis
  - Bill of Materials
  - Validation of Security Measures
- Deployment and Maintenance

Software Security Initiatives are a Journey



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Silicon to Software™

Expecting Secure, High-Quality Software:
Mitigating Risks throughout the Lifecycle by Reducing Attack Vectors

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