Workshop

Secure Coding

in .NET and .NET Core

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Your Host

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Organization

Material: https://github.com/rstropek/SecureCodingDotNet

Time Schedule

```
09:00-10:30
10:30-11:00 – Morning Break
11:00-12:30
12:30-13:15 – Lunch Break
13:15-14:45
14:45-15:15 – Afternoon Break
15:15-16:45
```

General Guidelines

How to Write Secure .NET Code

Don't be lazy. Think!

Avoid making stupid mistakes

Do take responsibility

Avoid delegating security measures to others (*DevSecOps*, infrastructure is code)

Don't miss the big picture

Avoid restrictive policies that lead to an overall lower level of security
E.g. security policies that force developers to run VS as administrators
E.g. proxies that lead to plain-text passwords in text files

Do handle PII with special care

Consider encryption whenever you store PII

How to Write Secure .NET Code

Don't build executable code using string concatination

HTML, JavaScript, SQL, etc.

Don't put secrets in unencrypted text files

Always use password keepers (for humans and apps)

Do setup CI/CD

Make sure CI/CD servers can be trusted

Containers: Automate rebuilding when base images change

Do write automated tests

Enables quick deployment of new versions and security patches

How to Write Secure .NET Code

Prefer PaaS and/or Serverless

Avoid IaaS

If IaaS cannot be avoided: Keep your system up to date (immutable infrastructure)

Don't invent your own encryption algorithms

or write your own implementation of an existing one

...unless it is your specific expertise

Don't invent your own security protocols

or write your own implementation of an existing one

...unless it is your specific expertise

How to Write Secure .NET Code

Do add logging and telemetry collection

- *Consider* using machine learning to detect suspicious user activities
- Be careful when adding PII to logs/telemetry (GDPR)
- *Avoid* writing secrets to logs/telemetry

Do validate user input

- Client *and* server

Cryptography

.NET Cryptography Model

Derived class hierarchy

Basic algorithm types (e.g. SymmetricAlgorithm, AsymmetricAlgorithm, HashAlgorithm)
Algorithm classes (e.g. Aes, RC2, ECDiffieHellman)
Algorithm implementations (e.g. AesManaged, RC2CryptoServiceProvider)

Different implementations

E.g. Aes → AesCng, AesCryptoServiceProvider, AesManaged
CryptoServiceProvider → wrapper around *Windows Crypto API* (*CAPI*); legacy
Managed → written entirely in managed Code; x-plat, slower, not certified
Cng → *Cryptography Next Generation* (*CNG*), Windows >= Vista, actively developed

See also Recommended algorithms by application

Stream Design

For symmetric and hash algorithms

CryptoStream

Derived from *System.IO.Stream*

Can be chained

E.g. hash, followed by encryption

Random Numbers

Pseudo-random numbers

System.Random
Predictable

Secure random numbers

RNGCryptoServiceProvider

See also https://lowleveldesign.org/2018/08/15/randomness-in-net/

bcrypt.net

https://github.com/BcryptNet/bcrypt.net

NuGet: *BCrypt.Net-Next*

Port of *jBCrypt* to C#

Used to safely store passwords

Hashing of passwords with configurable hash complexity

Compute power necessary for hashing can be set („work factor“)

Backward/forward compatible because complexity part of resultant hash

Examples

01-Symmetric-Encryption

Encrypt/decrypt data using AES

02-Asymmetric-Encryption

Transfer secret message using RSA and AES

03-Hashing

Compare two files using their SHA512 hash values

04-Signing

Create a signed hash value and verify it

Examples

05-RandomNumbers

Generating strong random numbers with *RNGCryptoServiceProvider*

06-BCrypt

Hash passwords with *BCrypt*

Protecting Secrets

How to protect connection information

General Guidelines

Prefer not storing secrets at all

- Windows Authentication
- Azure: Use AAD authentication with SQL (docs)
- Azure Managed Identities (docs)

Use Connection String Builders instead of string concat

- Sample: *07-ConnectionStringBuilders*
- Don't set *Persist Security Info=True* (default is False) to prevent security-sensitive information to be obtained from a connection

private/protected/internal is no protection

- See also *BindingFlags.NonPublic* (docs)

See also https://docs.microsoft.com/en-us/dotnet/framework/data/adonet/protecting-connection-information

General Guidelines

Recap .NET Core config system

08-RecapNetCoreConfig

Encrypt configuration files

ASP.NET: Use *aspnet_regiis* tool (docs)

ASP.NET Core *Secret Manager* tool (docs)

Stores secrets separated from application code

ASP.NET Core: *09.1-SecretManager*

dotnet user-secrets set "ping" "pong"

→ Show secrets in *%APPDATA%\Microsoft\UserSecrets\...*

See also https://docs.microsoft.com/en-us/dotnet/framework/data/adonet/protecting-connection-information

Environment Variables

Add non-critical defaults to config files (e.g. *appsettings.json*)

E.g. Connection string pointing to *LocalDB* with integrated security

Override settings in production using environment variables

Works on Azure

Works in containers (e.g. *docker run -e*)

Problem: Environment variables are not encrypted

If machine is compromised, environment variables can be accessed

Solution: Store secrets in vaults like *KeyVault*

Settings = environment variables only point to vault

Use integrated security of platform (e.g. Windows, Azure Managed Identity)

Azure Managed Identity

Automatically managed identities for services in Azure

- Backed by Azure AD
- Goal: No credentials on developer workstations or in source control

Two types: System- or user-assigned

- More or less control over service principal creation

Supported by more and more Azure PaaS/Serverless services

- Docs
- Here: Focus on KeyVault

See also https://docs.microsoft.com/en-us/azure/active-directory/managed-identities-azure-resources/overview

KeyVault

Keep secrets, encryption keys, and certs in Azure

Can be protected by certified HSMs

Monitor access and use

Integrated in various Azure services

E.g. SSL certs for App Service (docs)
E.g. *Always Encrypted* in SQL (docs)

Access to KeyVault can be protected by *Managed Identity*

Sample: *09.2-KeyVaultManagedIdentity*

See also https://docs.microsoft.com/en-us/azure/key-vault/key-vault-overview

KeyVault

KeyVault configuration provider

Merge secrets from KeyVault to configuration settings

Sample: *09.3-KeyVaultConfigurationProvider*

Adjust KeyVault name in *appsettings.json* if necessary

See also https://docs.microsoft.com/en-us/aspnet/core/security/key-vault-configuration?view=aspnetcore-2.2

Data Protection API

of ASP.NET Core

Overview

How to round-trip trusted state via an untrusted client?

E.g. Tokens

ASP.NET Core: *Data Protection API*

Symmetric encryption
In ASP.NET 4.x: *machineKey* Element in *web.config* (docs)
Can also be used as a replacement for *machineKey* (docs)

Functionality

Protect/unprotect strings (e.g. secrets)
Hash passwords (consider using *BCrypt* instead)
Algorithms and key management can be configured to specific needs

See also https://docs.microsoft.com/en-us/aspnet/core/security/data-protection/introduction?view=aspnetcore-2.2

Examples

10-NetCoreDataProtection

Use ASP.NET Core Data Protection API to protect/unprotect strings

11-DataProtectionPasswordHash

Calculate password hashes with ASP.NET Core Data Protection API

Configuration

Meaningful defaults for single-server deployments

Key persistance

- Azure Blob Storage
- Manual settings for file system (e.g. UNC path, *Azure Files*)

Key protection

- Protect using KeyVault keys
- Certificate

For details see https://docs.microsoft.com/en-us/aspnet/core/security/data-protection/configuration/overview?view=aspnetcore-2.2

Exceptions and Logging

Exceptions

New in C# 6: *Exception filtering*

Note: Filter runs before *finally*

Example: *12-ExceptionFilters*

Demonstrates order of execution in exceptions with filters

Recap: *IDisposable*, *using* statement

Necessary?

Docs

See also https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/keywords/try-catch

Logging – What?

Client requests and server responses

Helpful in reconstructing sequences of events

Account information

E.g. successful and failed authentication attempts, account changes, use of privileges

Usage information

E.g. number of transactions occurring in a certain period, size of transactions

Significant operational actions

E.g. application startup and shutdown, application failures (exceptions), major application configuration changes

See also https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-92.pdf

Logging Options

ASP.NET Core built-in logging

Docs

Log libraries

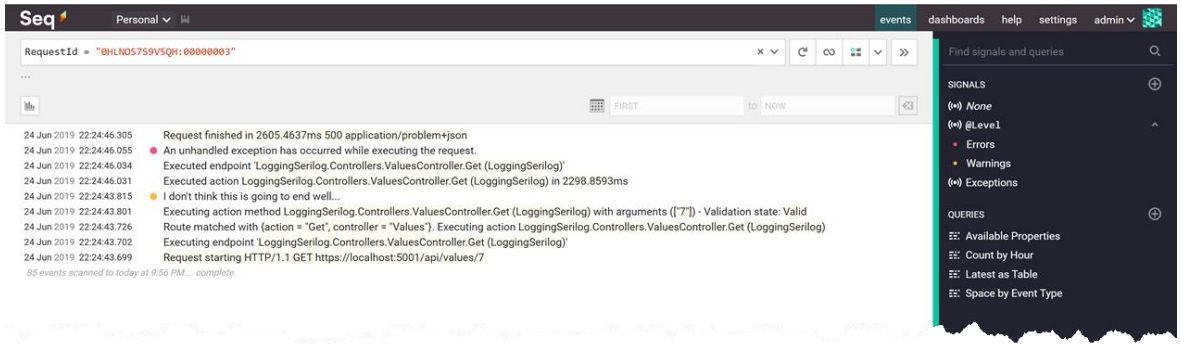
Here: Serilog

Many sinks available (list)

In Azure

Azure Monitor

Azure Application Insights



Example

13-LoggingSerilog

Add logging with *Serilog* to ASP.NET Core app
Includes log viewing with *Seq*

Database Security

Beware of SQL Injections

Guidelines

Do use parameterized SQL commands

Sample: *09.2-KeyVaultManagedIdentity*

Avoid concatenating SQL strings with user inputs

Do check user input

E.g. regular expressions

Do apply the *principle of least privilege* (*PoLP*)

Consider using an OR-Mapper like *Entity Framework*

Sample: *14-EntityFramework*

Database Encryption

Always Encrypted (docs)

- Client encrypts sensitive data inside client applications
- Never reveals the encryption keys to the DB

Transparent Data Encryption (docs)

- Real-time I/O encryption and decryption of the data and log files
- Make stolen physical storage media useless

Encrypted DB Connections (docs)

- Use certificate to encrypt DB connections
- Automatically done in *Azure SQL Database*

Data Protection

Dynamic Data Masking (docs)

Limits sensitive data exposure by masking it to non-privileged users

Roslyn Code Analyzer

Overview

Analyzes code for style, quality and maintainability, design, and other issues

Built-in analyzers in VS

- Configure in options and *.editorconfig*

Install additional analyzers with NuGet

- E.g. *FxCopAnalyzers* (docs)

Sample: *15-StaticCodeAnalysis*

- Detection of SQL Injection with code analysis
- Suppression management

See also https://docs.microsoft.com/en-us/visualstudio/code-quality/roslyn-analyzers-overview?view=vs-2019

Further Readings

Further Readings

.NET

.NET Secure Coding Guidelines
.NET Security Announcements

Web Development Security

ASP.NET Security Announcements
OWASP Security Cheat Sheet for .NET

Database Development

SQL Server Security Guidelines

Q&A

Thank your for coming!

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Saves the day.