SBA Research

Type-Driven Domain Modeling

Use the types, Luke!

Security Meetup – 2022-01-26

Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie
Bundesministerium Digitalisierung und Wirtschaftsstandort
FFG Forschung wirkt.
wirtschafts agentur wien Ein Fonds der Stadt Wien
European Commission
FWF Der Wissenschaftsfonds.
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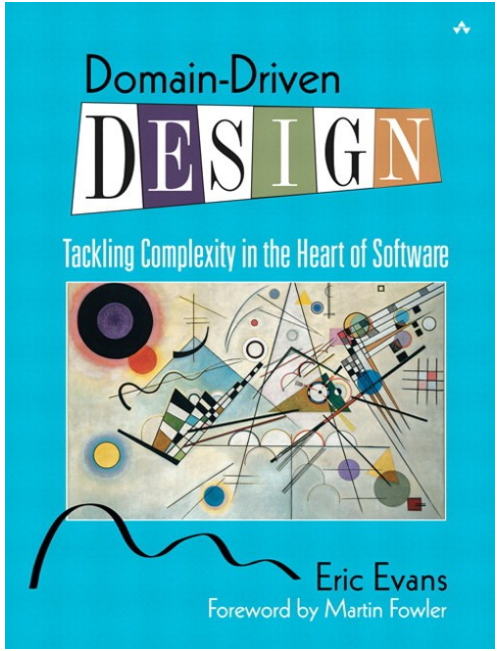
Introduction

Wisdoms from the Blue Book

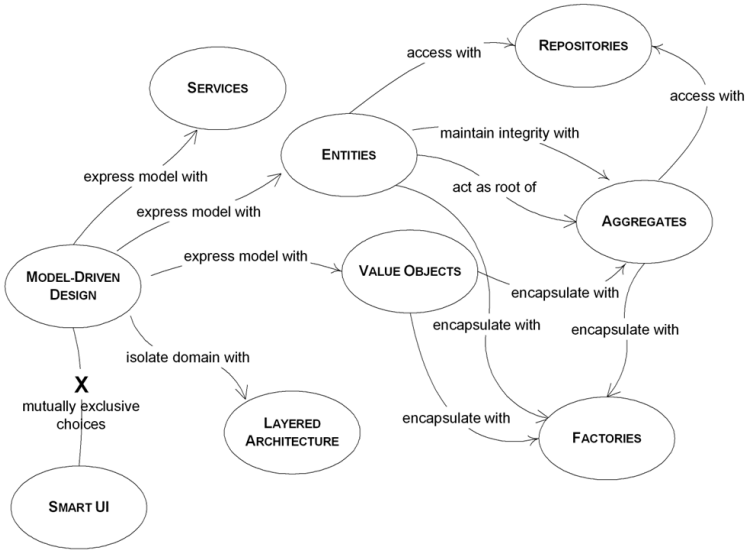


Domain-Driven Design (DDD)

- Code and structure should match the business domain
- Primary focus on core domain and business logic
- Iteratively refine concepts by consulting domain experts
- Uses ubiquitous language that everyone in the domain understands

Popular Concepts

- Entity
- Value object
- Aggregate
- Bounded Contexts
- Repository
- Command Query Responsibility Segregation



Source: Domain-Driven Design – Eric Evans

Type-Driven Domain Modeling

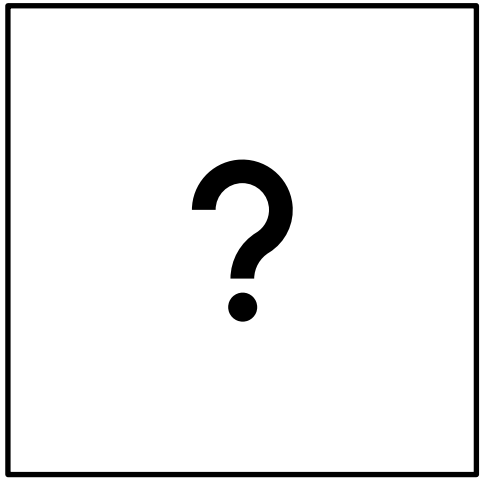
- Encode business rules into types
- Make illegal state unrepresentable
- Reason without looking at implementations
- Prevent security vulnerabilities
- Offload work to the compiler

Language Support

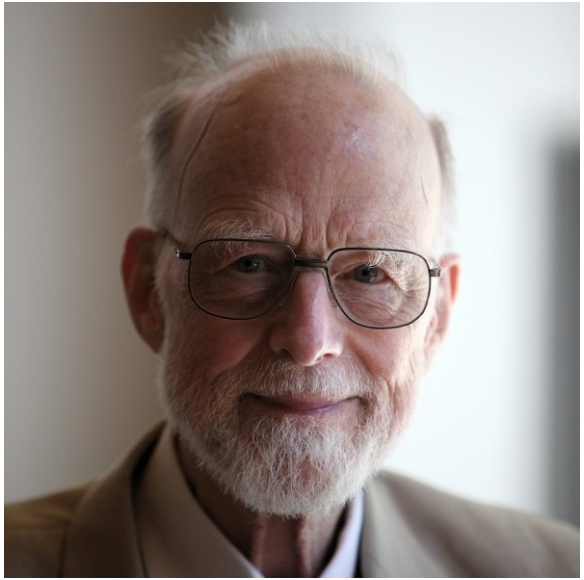
- Any language can be used for DDD
- But some provide more powerful type systems
- Nice to have: Sum Types, Pattern Matching

- Examples:
  - Haskell
  - Elm
  - OCaml
  - F#
  - Rust
  - Scala
  - Reason
  - TypeScript
  - C# (7)
  - Java (17)

Null



Null



Source: https://commons.wikimedia.org/wiki/File:Sir_Tony_Hoare_IMG_5125.jpg

"I call it my billion-dollar mistake. It was the invention of the null reference in 1965."
Tony Hoare

Make the Absence of Values Explicit (Haskell)

```haskell
data Maybe a = Nothing | Just a

lookup :: String -> [(String, String)] -> Maybe String
lookup key list = case list of
    []             -> Nothing
    ((k, v):rest) -> if key == k then Just v else lookup key rest

phonebook :: [(String, String)]
phonebook = [("Alice", "01889 985333"), ("Bob", "01788 665242")]

getNumber :: String -> [(String, String)] -> String
getNumber name list = case lookup name list of
    Nothing    -> "Could not find a number for " <> name
    Just value -> name <> "’s number is: " <> value
```

Modeling a Contact Type

Because not everything is a string

Demo Time

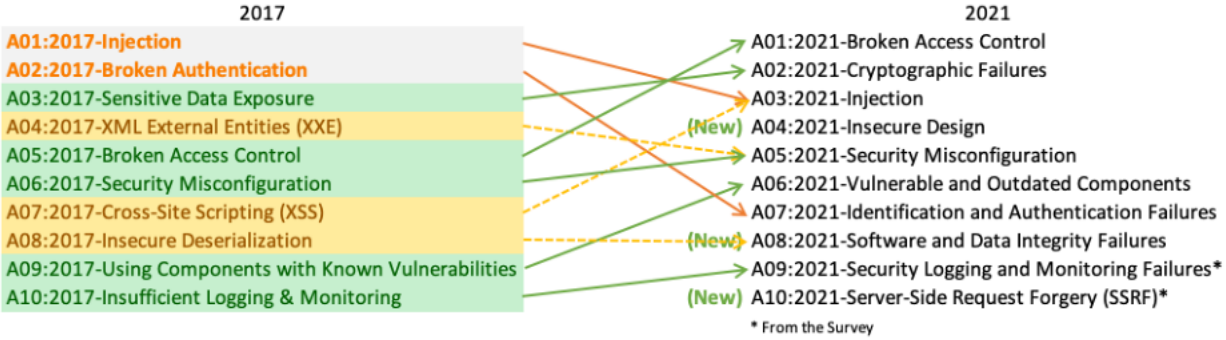
Domain modeling in F#

Typed Security

Preventing vulnerabilities by design

OWASP Top Ten (2021)

- A01:2021-Broken Access Control
- A03:2021-Injection
- A04:2021-Insecure Design



Source: https://owasp.org/Top10/

OWASP API Security Top 10 (2019)

- API1:2019 Broken Object Level Authorization
- API3:2019 Excessive Data Exposure
- API5:2019 Broken Function Level Authorization
- API6:2019 Mass Assignment
- API8:2019 Injection

Demo Time

Haskell

Fighting broken access control attacks

Fighting Injection Attacks (Haskell)

```haskell
import qualified Database.SQLite.Simple as SQL

main = SQL.withConnection "products.db" $ \conn -> do
    putStrLn "Search by product name:"
    pname    <- getLine
    products <- getProductsByName conn pname
    putStrLn ("Here is the data: " ++ show products)

-- SQL.query :: SQL.Connection -> SQL.Query -> args -> IO [result]

getProductsByName :: SQL.Connection -> String -> IO [Product]
getProductsByName conn pname =
    SQL.query conn (SQL.Query "SELECT * FROM products WHERE product_name=?") (pname)
```

Fighting Excessive Data Exposure (Java)

```
1.  public class User {
2.      private final Id<User> id;
3.      private Name50 firstName, lastName;
4.      private Birthdate dateOfBirth:
5.      private PasswordHash passwordHash;
6.      // Constructor, getters, setters, domain logic, etc.
7.  }
8.  public class UserViewModel {
9.      private final String fullName;
10.     private final DateTime dateOfBirth;
11.     // Constructor, getters, mapping from entity to dto and vice versa
12. }
13. public List<UserViewModel> getUsers(...) {
14.     List<User> users = userService.getUsers(...);
15.     return users.stream().map(UserViewModel::entityToViewModel).collect(Collectors.toList());
16. }
```

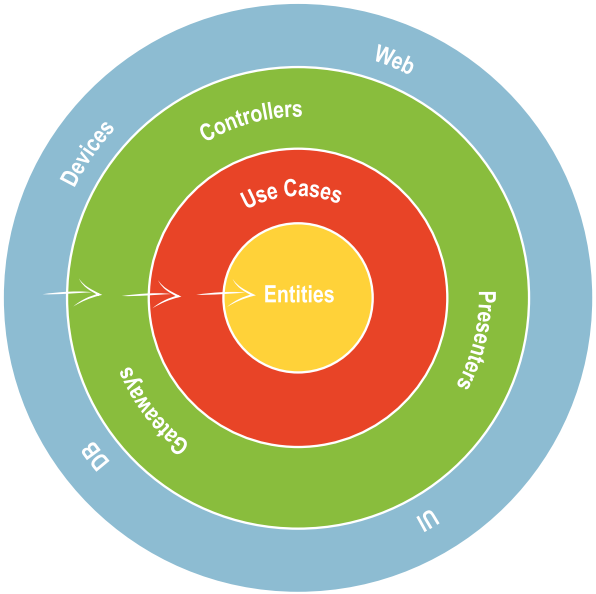
Fighting XSS Attacks (Elm)

```
1.  -- div : List (Attribute msg) -> List (Html msg) -> Html msg
2.  -- text : String -> Html msg

3.  userComponent : String -> Int -> Html msg
4.  userComponent userName userAge =
5.      div [ class "user-component" ]
6.          [ text userName
7.          , text (String.fromInt userAge)
8.          ]

9.  -- <div class="user-component">Foo42</div>
```

Choosing the Right™ Architecture

Building on SOLID principles

Hexagonal / Onion / Clean Architecture



Source: https://www.4soft.de/blog/2019/clean-architecture/

Example Repository: PackIT (C#)

- PackIT.Api
  - Controllers
  - Properties
  - appsettings.Development.json
  - appsettings.json
  - PackIT.Api.csproj
  - Program.cs
  - Startup.cs
- PackIT.Application
  - Commands
  - DTO
  - Exceptions
  - Queries
  - Services
  - Extensions.cs
  - PackIT.Application.csproj
- PackIT.Domain
  - Consts
  - Entities
  - Events
  - Exceptions
  - Factories
  - Policies
  - Repositories
  - ValueObjects
  - PackIT.Domain.csproj
- PackIT.Infrastructure
  - EF
  - Logging
  - Services
  - Extensions.cs
  - PackIT.Infrastructure.csproj
- PackIT.Shared
- PackIT.Shared.Abstractions

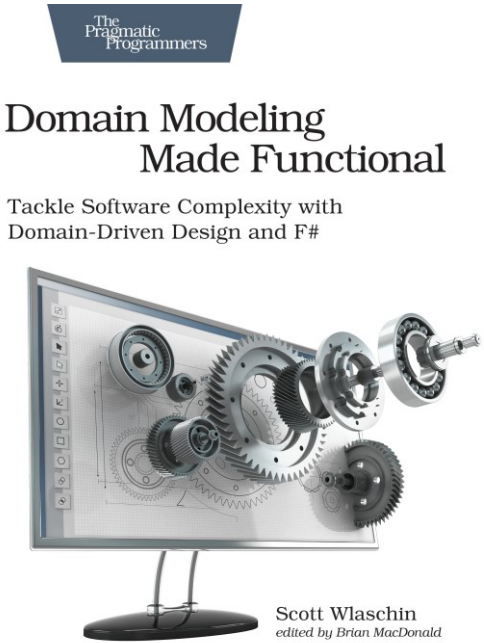
- PackIT.Application
  - Commands
    - Handlers
    - AddPackingItem.cs
    - CreatePackingListWithItems.cs
    - PackItem.cs
    - RemovePackingItem.cs
    - RemovePackingList.cs

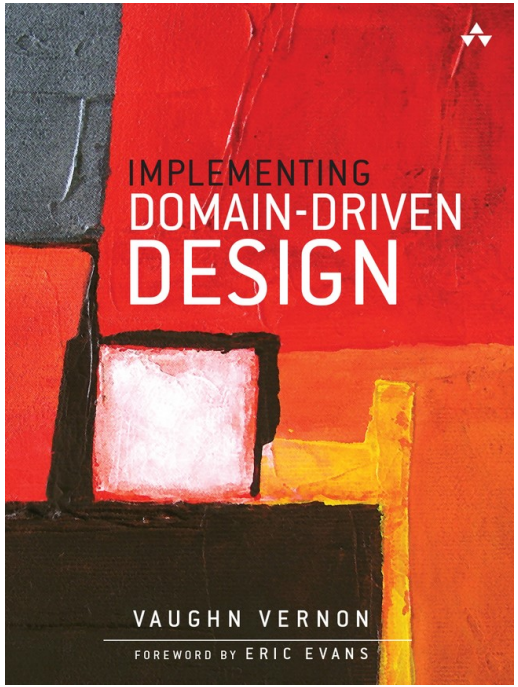
```csharp
using PackIT.Domain.Exceptions;

namespace PackIT.Domain.ValueObjects
{
    public record PackingItem
    {
        public string Name { get; }
        public uint Quantity { get; }
        public bool IsPacked { get; init; }

        public PackingItem(string name, uint quantity, bool isPacked = false)
        {
            if (string.IsNullOrWhiteSpace(name))
            {
                throw new EmptyPackingListItemNameException();
            }

            Name = name;
            Quantity = quantity;
            IsPacked = isPacked;
        }
    }
}
```

```csharp
using System.Threading.Tasks;
using PackIT.Application.Exceptions;
using PackIT.Domain.Repositories;
using PackIT.Domain.ValueObjects;
using PackIT.Shared.Abstractions.Commands;

namespace PackIT.Application.Commands.Handlers
{
    internal sealed class AddPackingItemHandler : ICommandHandler<AddPackingItem>
    {
        private readonly IPackinglistRepository _repository;

        public AddPackingItemHandler(IPackingListRepository repository)
            => _repository = repository;

        public async Task HandleAsync(AddPackingItem command)
        {
            var packingList = await _repository.GetAsync(command.PackingListId);

            if (packingList is null)
            {
                throw new PackingListNotFoundException(command.PackingListId);
            }

            var packingItem = new PackingItem(command.Name, command.Quantity);
            packingList.AddItem(packingItem);

            await _repository.UpdateAsync(packingList);
        }
    }
}
```


Source: https://www.youtube.com/watch?v=NzcZcim9tp8

Book Recommendations





Key Takeaways

- Make illegal state unrepresentable
- Encode business rules in your types
- Parse, don’t validate
- Use the compiler to your advantage
- Write readable code for domain experts
- Eliminate security vulnerabilities by design

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