MATHEMA

Wir testen. Aber testen wir auch gut genug?

Eine Einführung in Mutation Testing mit Stryker.NET

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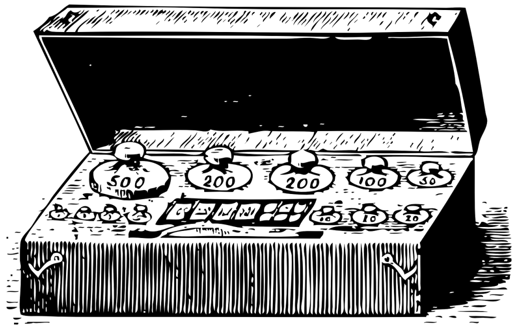
- Software Entwickler
- Beruflich: C#
- Interessen:
  - Software Crafting
  - Test-Driven Development
  - Funktionale Programmierung
  - Domain-Driven Design
- Slides sind online: Siehe QR-Code

Let’s talk about "Metrics"...

https://www.nngroup.com/articles/campbells-law/

- "It is wrong to suppose that if you can’t measure it, you can’t manage it - **a costly myth**." - W. Edwards Deming
- **Campbell’s Law** states that **the more important a metric is** in social decision making, the **more likely it is to be manipulated**.
- **Goodhart’s Law** states that **"When a measure becomes a target, it ceases to be a good measure"**

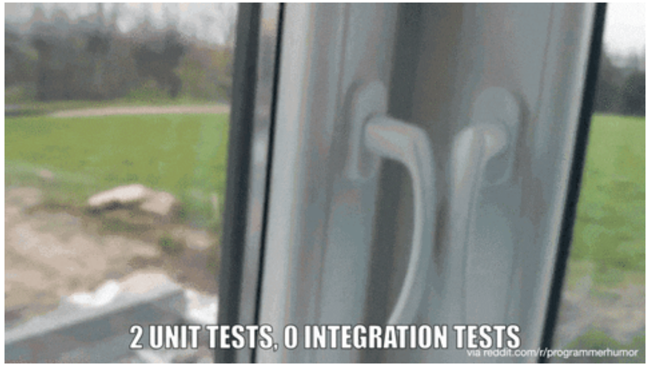


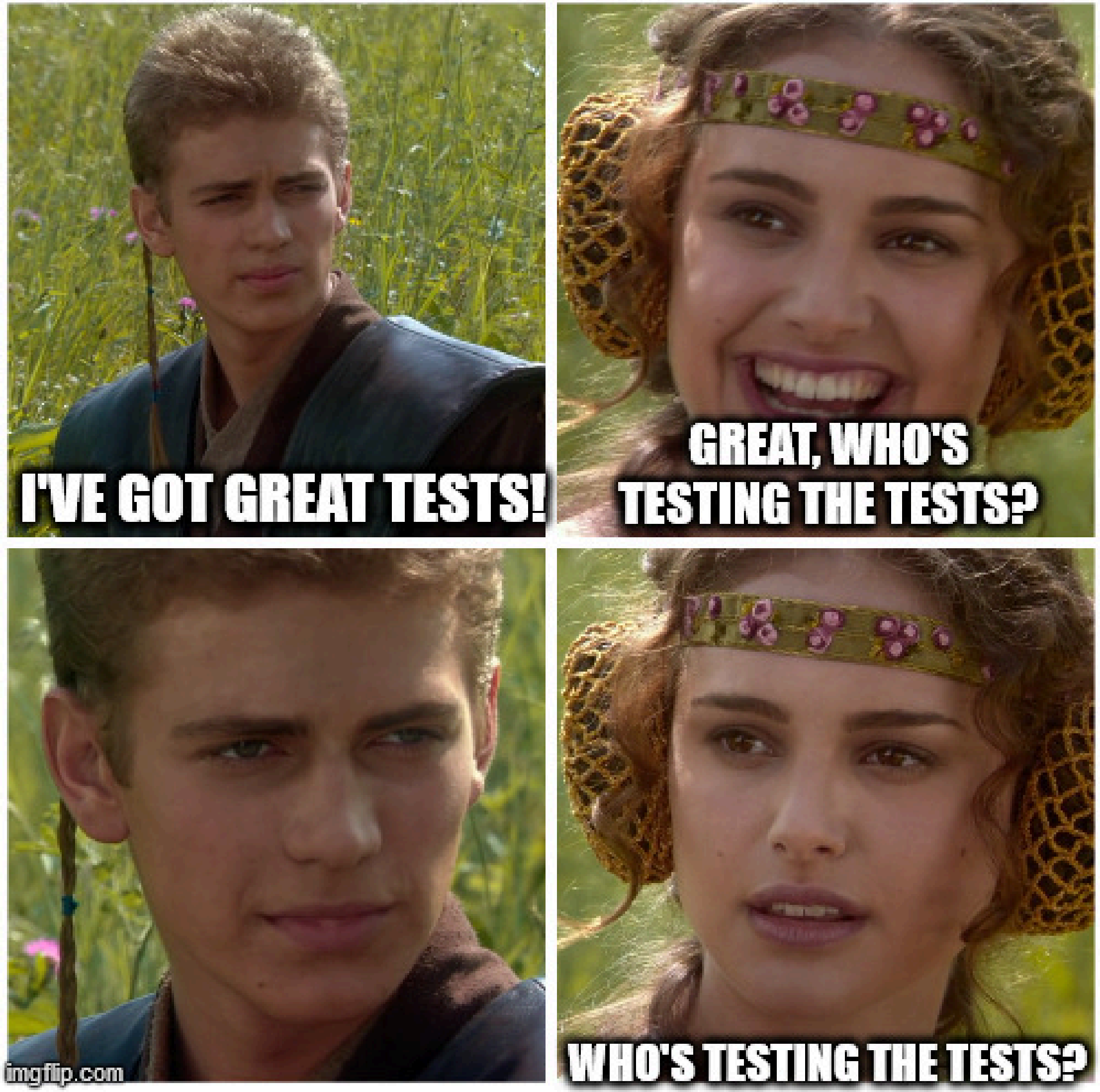
Test coverage

- 🎓 defines the percentage of covered code
- ✅ 100% test coverage means, every line of code is executed at least once
- ⚠ 100% test coverage **does not mean that every scenario / use-case is covered**

Is Test coverage a "good metric"?

- not every line of code needs to be tested
- BUT: having no tests is obviously also not a good idea
- anything above 60% is a good baseline (but, "it depends")
- test coverage does not tell us anything about the **quality** of the tests


2 UNIT TESTS, 0 INTEGRATION TESTS
via reddit.com/r/programmerhumor


I'VE GOT GREAT TESTS!
GREAT, WHO'S TESTING THE TESTS?
WHO'S TESTING THE TESTS?
imgflip.com

What is mutation testing?

https://stryker-mutator.io/docs/

- Mutation testing **introduces changes to your code**, then runs your unit tests against **the changed code**.
- the "change" is called a **mutant**
- If our test suite is ok for a "mutant:" Ups, we missed something

Hello-World Example

Production code:

```
public string DoMagic(int i) ⇒ i < 18 ? "child" : "adult"
```

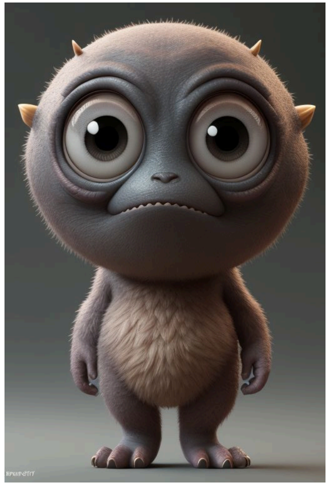
- `dotnet stryker`
- it creates a mutant replacing `<` with `<=`

```
public string DoMagic(int i) ⇒ i ⩽ 18 ? "child" : "adult"
```

- The mutant "survived"
- The mutant did not provoke a test failure!
- ⚠ Our test suite might not be good enough! ⚠

Test suite (**100% code coverage!**):

```
[Theory]
[InlineData(10, "child")]
[InlineData(20, "adult")]
public void DoMagic_works(int input, string expected)
{
  DoMagic(input).Should().Be(expected)
}
```



Mutations

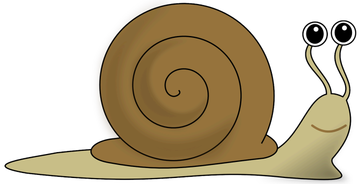
Let's have a look at mutations: https://stryker-mutator.io/docs/stryker-net/mutations/

Most mutations are language agnostic

Some are optimized for .NET:

- Initializers
- Removal
- Linq
- Null-coalescing Operators

Isn’t this slow?



- Short answer: YES
- BUT: **These frameworks have smart heuristics for short circuiting**
- CI: Don’t include this in normal commits
- CI: use "Nightly", or local (for **exploratory analysis**)
- Google uses Mutation Testing on really large projects: https://research.google/pubs/practical-mutation-testing-at-scale-a-view-from-google/
  - "... a codebase of **two billion lines of code** and more than **150,000,000 tests**"
  - "... used by more than **24,000 developers** on more than **1,000 projects**"
  - It is still slow, but not as slow as you might think
  - 🎧 SE Radio 632: Goran Petrovic on Mutation Testing at Google:
    - https://se-radio.net/2024/09/se-radio-632-goran-petrovic-on-mutation-testing-at-google/

Mutation Strategies

🤔 How do these frameworks optimize performance?

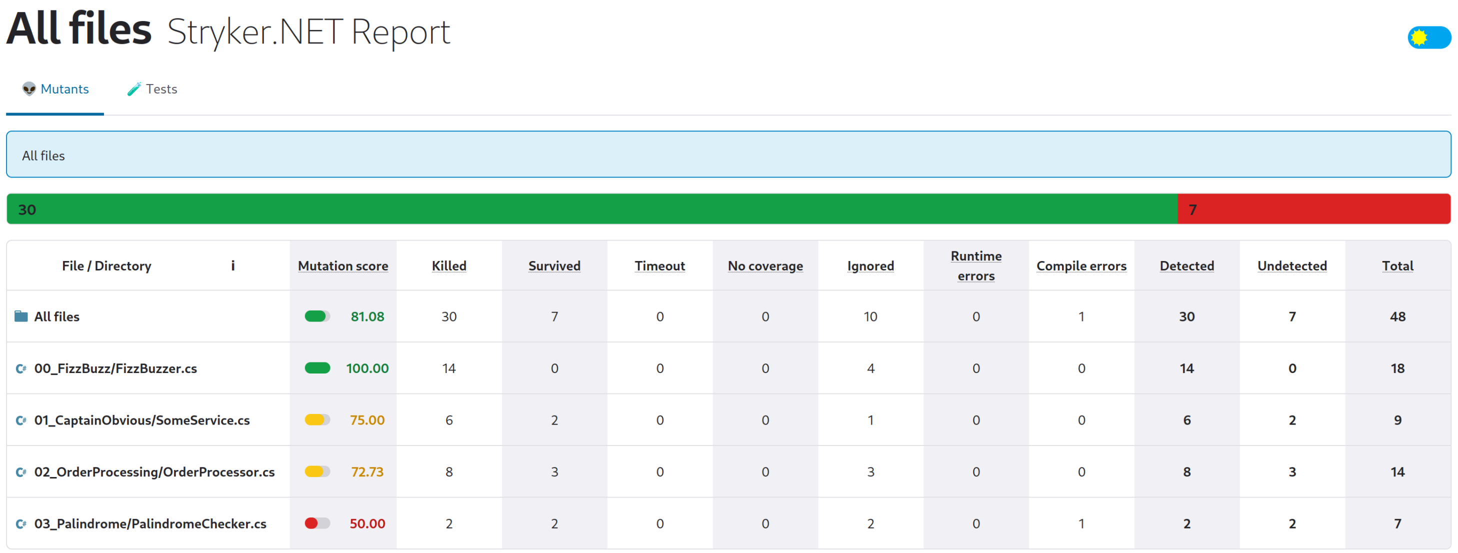
https://stryker-mutator.io/docs/stryker-net/technical-reference/research/#comparison

- mutate **source code**
- mutate **byte code**
- **mutant schemata** (aka "mutant switching")

👉 Stryker.NET uses "mutant schemata"

Live coding

Reports: HTML (Overview)



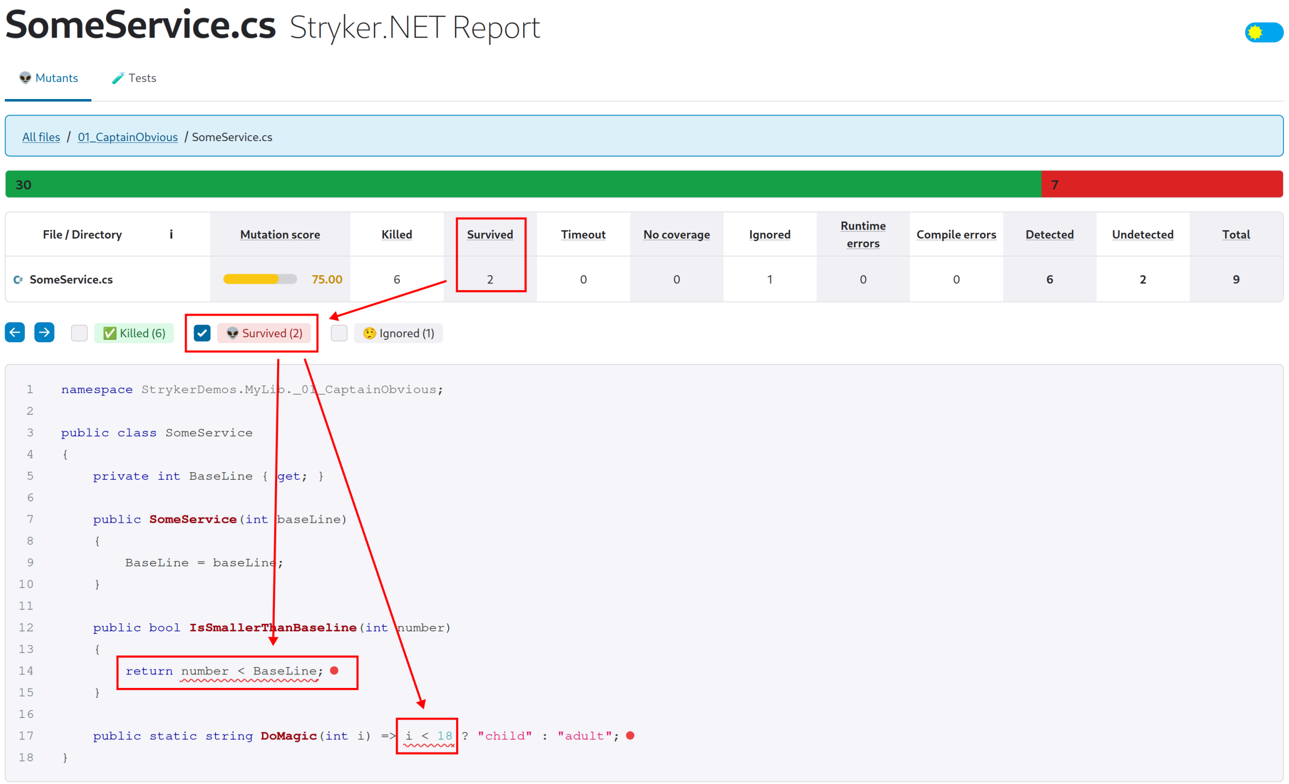
All files Stryker.NET Report

All files

30 7

File / Directory	Mutation score	Killed	Survived	Timeout	No coverage	Ignored	Runtime errors	Compile errors	Detected	Undetected	Total
All files	81.08	30	7	0	0	10	0	1	**30**	**7**	**48**
00_FizzBuzz/FizzBuzzer.cs	100.00	14	0	0	0	4	0	0	**14**	**0**	**18**
01_CaptainObvious/SomeService.cs	75.00	6	2	0	0	1	0	0	**6**	**2**	**9**
02_OrderProcessing/OrderProcessor.cs	72.73	8	3	0	0	3	0	0	**8**	**3**	**14**
03_Palindrome/PalindromeChecker.cs	50.00	2	2	0	0	2	0	1	**2**	**2**	**7**

Reports: HTML (Details)



SomeService.cs Stryker.NET Report

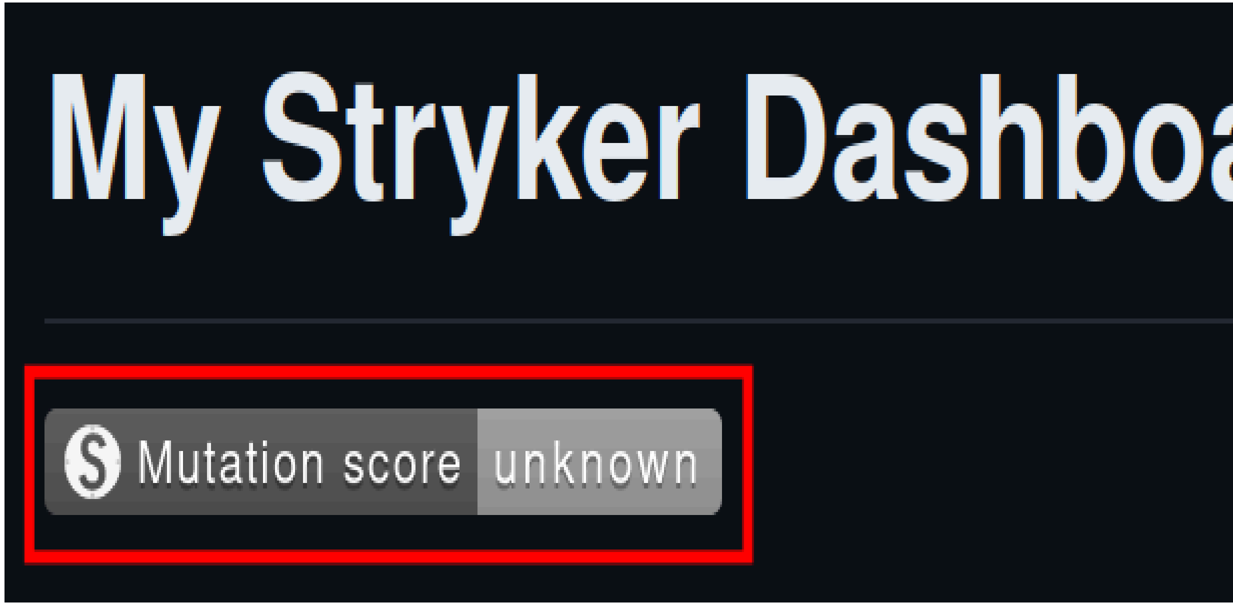
All files / 01_CaptainObvious / SomeService.cs

File / Directory	Mutation score	Killed	Survived	Timeout	No coverage	Ignored	Runtime errors	Compile errors	Detected	Undetected	Total
SomeService.cs	75.00	6	2	0	0	1	0	0	**6**	**2**	**9**

```
namespace StrykerDemos.MyLib._01_CaptainObvious;

public class SomeService
{
    private int BaseLine { get; }

    public SomeService(int baseLine)
    {
        BaseLine = baseLine;
    }

    public bool IsSmallerThanBaseline(int number)
    {
        return number < BaseLine; ●
    }

    public static string DoMagic(int i) => i < 18 ? "child" : "adult"; ●
}
```

Other Reporters

- Json (basis for HTML)
- Progress
- Cleartext
- Cleartext tree
- Dots (for CI)
- Markdown
- Dashboard



Fine-Tuning

🔧 Stryker provides many bells & whistles for fine-tuning using either CLI or config file.

Some examples:

- `mutate`: Globbing patterns for including/excluding
- `test-case-filter`: filter selective subset(s) of tests
- `mutation-level`: high level categories (`Basic`, `Standard`, `Advanced`, `Complete`)
- `coverage-analysis`: short circuit logic vs "everything in isolation"

Also nice: use git as baseline, only test things that have changed recently

- `since`: git "committish" (i.e. commit hash, tag, etc)
- `with-baseline` (experimental): similar to `since`, but uses previous reports

What about F#?

- The team noticed they had to rearchitect the framework (.NET is not only C#)
- This is a good thing!
- Strategy is clearly communicated!
- 🥳

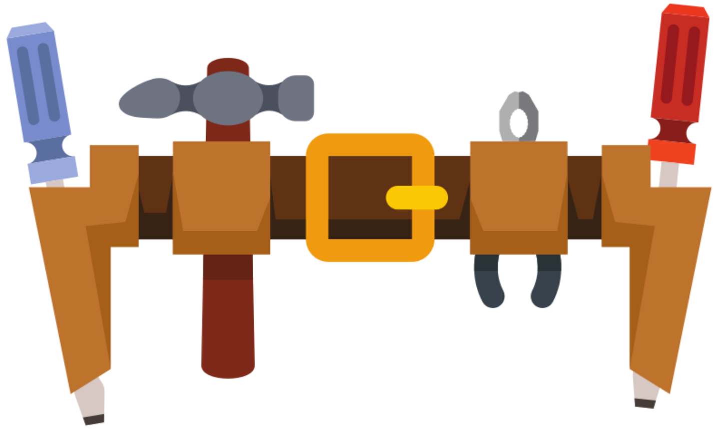
Mutation Testing: Available in many languages

Overview: https://github.com/theofidry/awesome-mutation-testing

- JavaScript: https://stryker-mutator.io/docs/stryker-js/
- Scala: https://stryker-mutator.io/docs/stryker4s/
- Java: https://pitest.org/
- Python: https://mutatest.readthedocs.io
- C/C++: https://github.com/mull-project/mull
- Rust: https://mutants.rs/
- Go: https://github.com/zimmski/go-mutesting
- Haskell: https://hackage.haskell.org/package/MuCheck
- etc. (search for "your-programming-language mutation test")

Mutation Testing: Summary

- 😎 none-invasive: no code changes required!
- 🔎 great for discovering important corner cases
- 🤔 requires a lot of resources: use wisely
- 🥳 great addition to our "Testing Toolbelt"
  - Test-Driven Development (TDD)
  - Approval Testing
  - Property-Based Testing (PBT)



Thank You!

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Slides 👇

- QR Code or
- https://draptik.github.io/2024-09-seneca-mutation-testing/
- sample code: https://github.com/draptik/2024-mutation-testing

Image sources: pixabay.com and perchance.org/ai-photo-generator