Code Analysis

Reflect on Your Code

Abstract

Most of the time developers produce code, but they rarely manage to adequately review their code to a high level of quality.
I aim to introduce simple analysis insights (such as code metrics, complexity, etc...) and present some crucial tools which really pay-off for medium-large scale code-bases.
Simple concepts such as code-reuse and re-factoring, although much discussed in the community, are still not thoroughly understood/employed by developers.
This is especially obvious when analyzing common open-source projects (.NET).
I'll illustrate how a very rigorous process of code review and continuous refactoring have a huge impact.

Disclaimer/Delimitation

- The author does not have significant experience to provide personal judgements over specific matter

- Introductory, no in-depth worked example

Plan

- Introduction
- Code Metrics
- Refactoring
- Tools
  - VS Ultimate
  - NDepend
- Conclusion

Introduction

Complexity - Accidental

Remember the evolution:

- Assembly
- High level/order
- Garbage collection
- Domain specific

Complexity - Essential

```
bubbleSort( A : list of items )
      n = length of A
      set swapped false
      repeat
            for i = 2 to n-1 inclusive do
              if A[i-1] > A[i] then
                swap A[i-1] with A[i]
                set swapped to true
              end if
            end for
      until not swapped
end
```

Interrelation

Analysis ⇔ Refactoring ⇔ Testing

Code Metrics

Problems

- Technical Debt
- Code Smells
  - Large classes
  - Long names
  - 5 indentation levels…
- Copy-paste code reuse

Software

```
output = function X(input)  {
        //Local work
        //Global work
}
```

Example - from OOP

No global => functional => fail

How would a functional method look like?

```
class X {
        output = Method(input)
}
```

Example - to functional

1.st step

```
output = Method(this, input)
```

2nd step

```
output = Method(global, this, input)
```

Software Engineering - Tom DeMarco

“*Software development is*
and always will be somewhat experimental.”

Code Metrics

- Lines of code
- Cyclomatic Complexity
- Maintainability Index

+ etc…

Code Metrics - LOC + extensions

Example

```
for (i = 0; i < 100; i++) printf("hello");

/* Versus */
for (i = 0; i < 100; i++)
{
    printf("hello");
}
```

Code Metrics - LOC

RefactorExample 1

```
public enum DanishMonths
{
  JANUAR, FEBRUAR, MARTS,
  APRIL, MAJ, JUNI,
  JULI, AUGUST, SEPTEMBER,
  OKTOBER, NOVEMBER, DECEMBER
}
```

RefactorExample 1 - Refactored

```
var culture =
CultureInfo.GetCultureInfo("da-DK");

var dateTimeInfo =
DateTimeFormatInfo.GetInstance(culture);

var months =
dateTimeInfo.CurrentInfo.MonthNames;
```

Code Metrics - Halstead Volume

$$V = N \times \log_2 \eta$$

N = operators + operands
η = distinct (operators + operands)

Code Metrics - Halstead Volume

Example

```
var x, y
var z = f(x, y)
z = (x+y/2)/3
f2(z)
```

N = (2+1+1+2+1+1+1)+(3+3+3) = 18

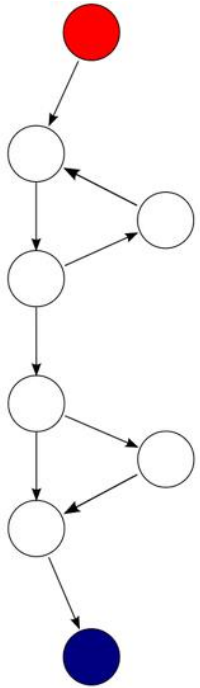
η = 7 + 3 = 10; {(), +, /, =, var, f, f2}, {x, y, z}

=> V = 10 * log(10) = 59.7

Code Metrics - Cyclomatic Complexity

M = E − N + 2P
E = edges.
N = nodes.
P = connected components(cycles).

=> 9-8+2*1=3



Code Metrics - Cyclomatic Complexity

Example:

```
while( c1() )  f1();

if( c2() ) f3();
else f4();
```

Code Metrics - Cyclomatic Complexity

Deceiving

- non-disjoint Ifs
- not accounting for libraries

Testing

- will complexity += 1 => tests += 1? (hint:**no!**)
- code/branch/path coverage...

Code Metrics - Cyclomatic Complexity

Example

```
var c
if( c1() )  x = f1();
else x = f2();
if( c2() ) y = f3();
else y = f4();
if( c3(x, y) ) f5();
else f6();
```

Code Metrics - Cyclomatic Complexity

Further useful for improving

- Time to fix bugs
- Regressing bug

Code Metrics - Cyclomatic Complexity

RefactorExample 2

```
private string MapBathRooms(string value) {
        double retValue = 0;
        if (value == "1" || value == "One")
                retValue = 1;
        if (value == "OneAndHalf" || value == "1.5" || value == "1 1/2")
                retValue = 1.5;

        //... Up to 10

        return retValue.ToString();
}
```

RefactorExample 2 - Refactored

```
Dictionary<string, string> BathRoomMap = new Dictionary<double,
List<string>>
{
    { 1, new List<string>() {"1", "One" }
    { 1.5, new List<string>() {"1 1/2", "OneAndHalf" },
    // etc
};
private string MapBathRooms(string value) {
        var retKeyValue = BathRoomMap.GetKeyValues()
                .SingleOrDefault(x=>x.Contains(value))

        if(retKeyValue==0) return 0;
        return retKeyValue.Key;
}
```

Code Metrics - Maintainability Index

$$171 - 5.2 ln(\text{HV}) - 0.23 \text{CC} - 16.2 ln(\text{LOC}) + 50.0 sin \sqrt{2.46 * \text{COM}}$$

Problems?

- 1 - magic numbers
- 2 - averages
- ..
- n

Code Metrics - Empirical Research

“Empirical Analysis of CK Metrics for Object-Oriented Design Complexity”

=> some correlation, interdependence

“Empirical Analysis of Object-Oriented Design Metrics for Predicting High and Low Severity Faults”

=> some correlation, most with SLoC

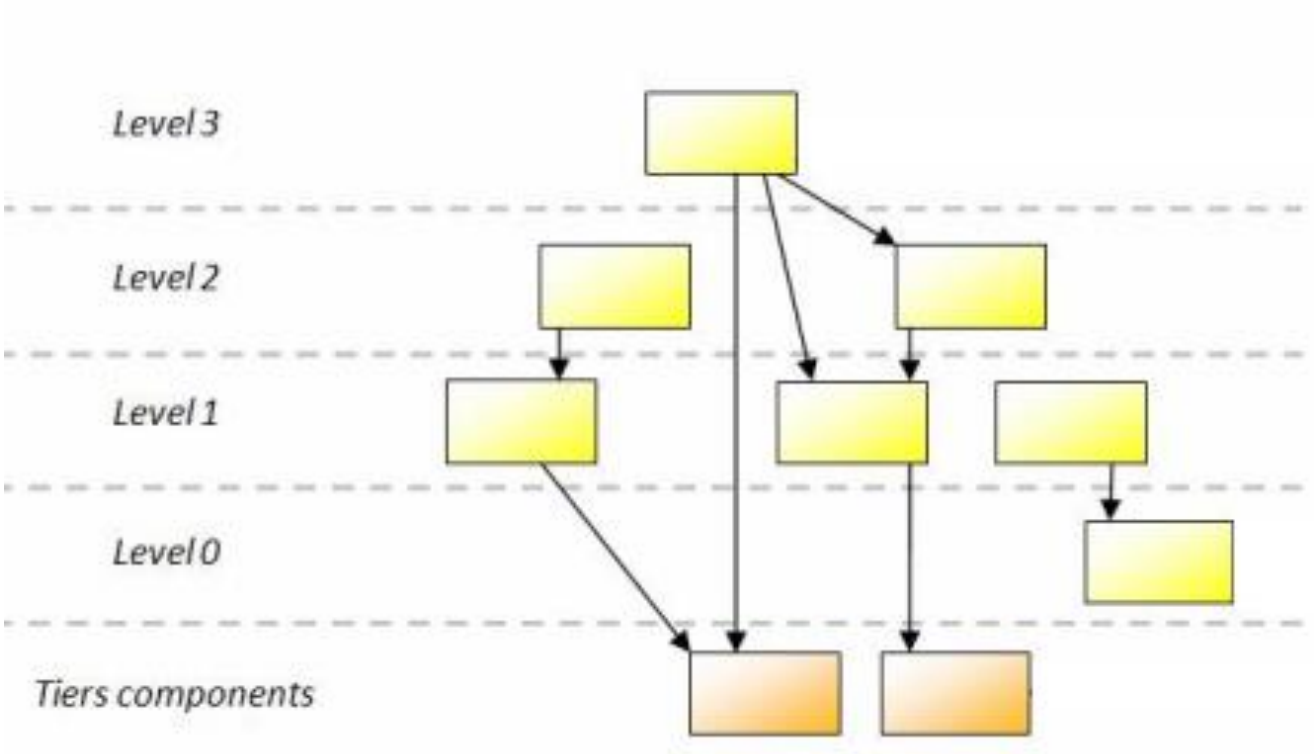
Code Metrics - Empirical Research

“Questioning Software Maintenance Metrics: A Comparative Case Study”

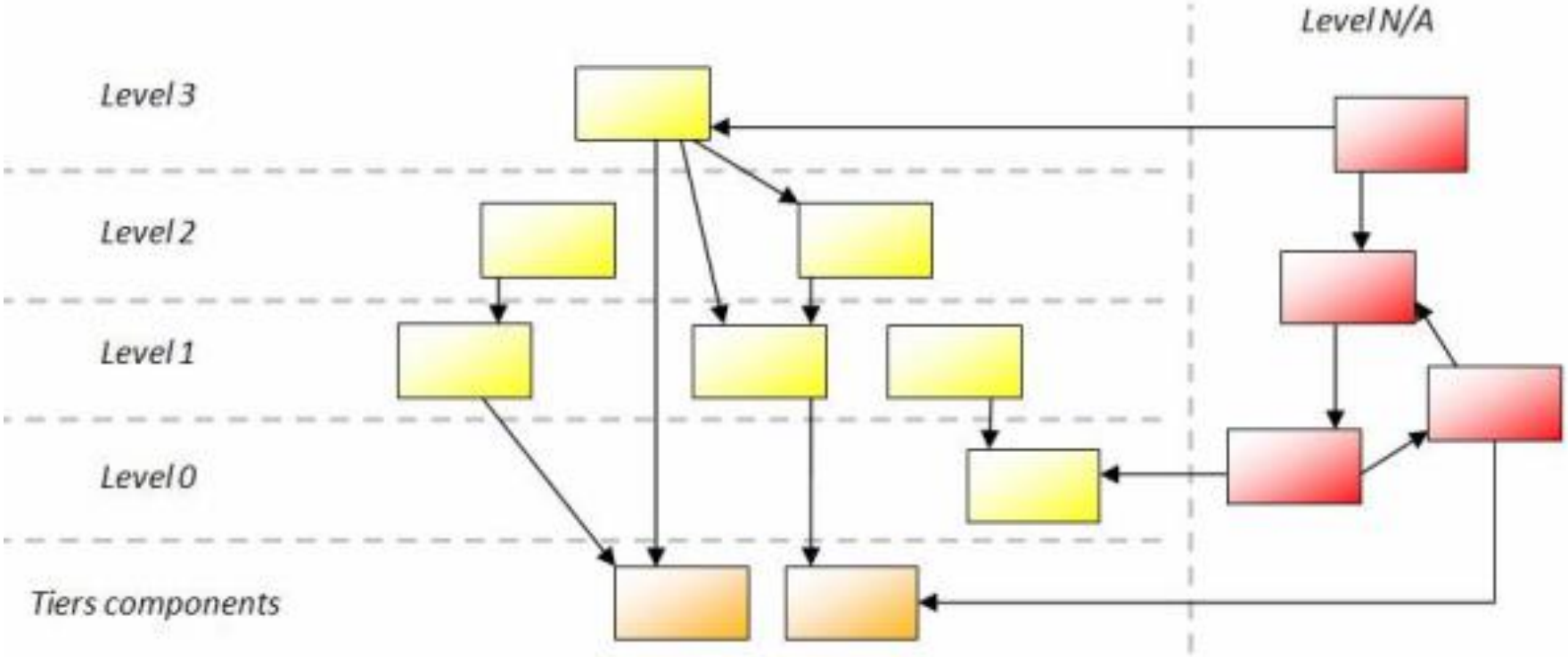
=> Only system size and low cohesion were strongly associated with increased maintenance effort”

=> quote more research...

Software Architecture - Ideal



Software Architecture - Cycles



Coupling

Any Methods, Types, Namespaces that have a direct reference to

- Fields, Methods, Types, Namespaces

Depending on direction: afferent or efferent

Metrics

- Stability

$$I = \frac{C_e}{C_a + C_e}$$

  - Couplings (dependencies) – afferent/efferent
- Abstractness

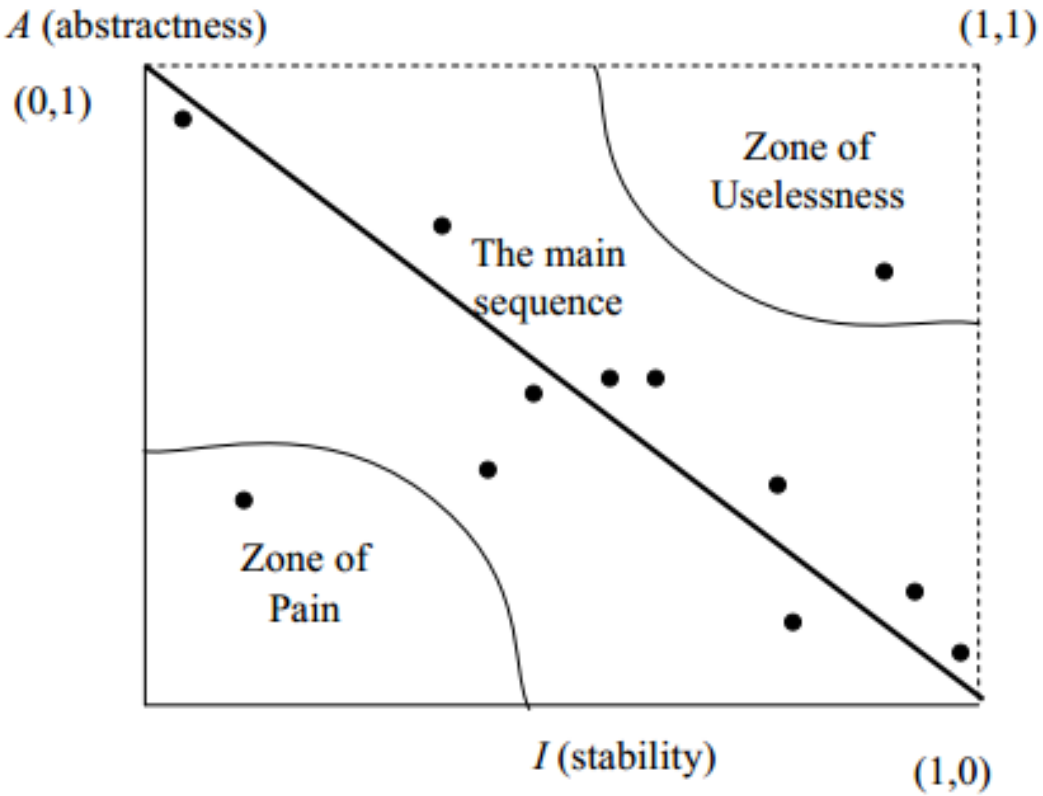
$$A = \frac{N_a}{N_c}$$

  - Types - abstract/concrete

Principles

- Stable Abstractions Principle – stability should match abstractness as close as possible
- Stable Dependencies Principle – fewer dependencies on fast-changing types

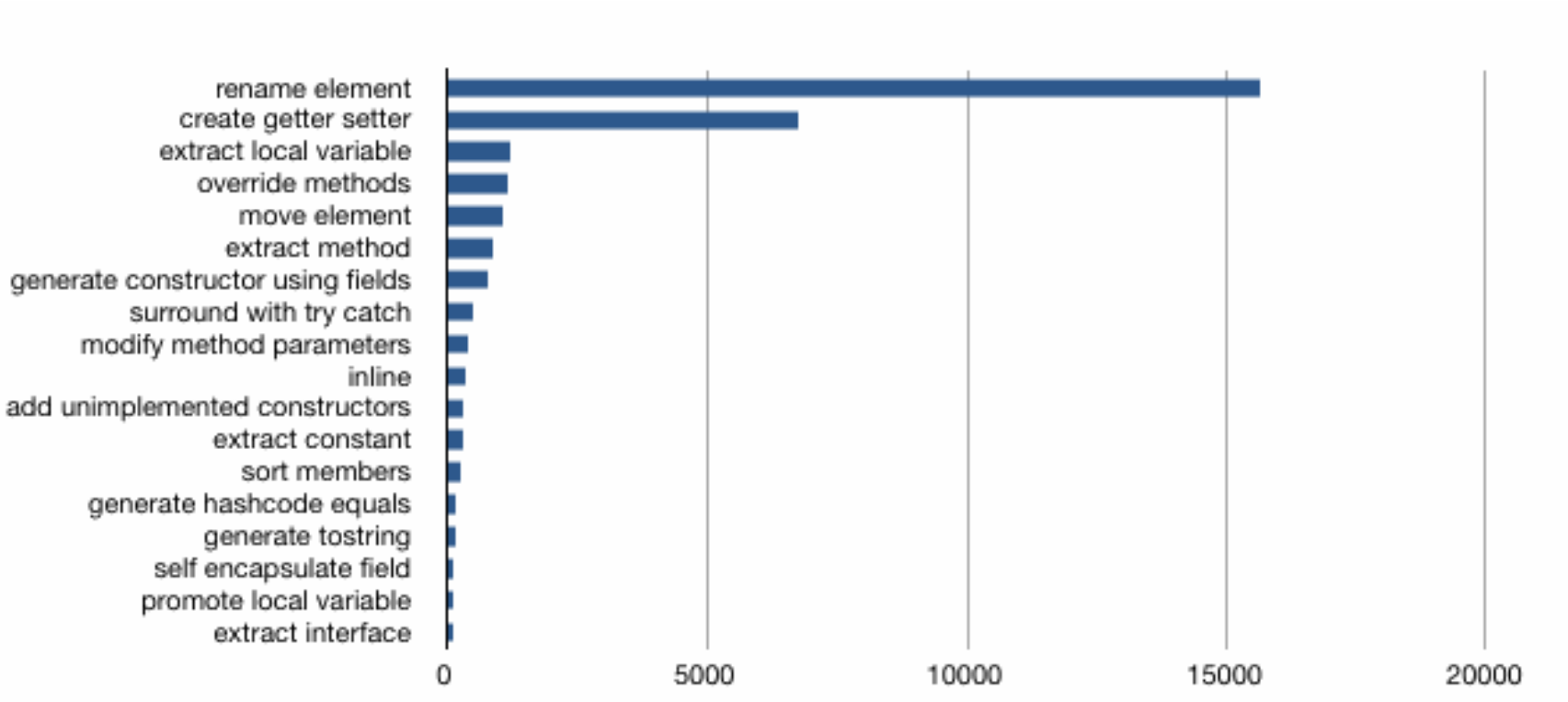
Software Architecture – done right



Refactoring

Part 2

Refactoring Methods



Refactoring - Empirical Research

“*A Field Study of Refactoring Challenges and Benefits*” by Microsoft, Windows 7 =>

"The difficulty of merging and integration after refactoring often discourages people from doing refactoring"

"If there is insufficient documentation for scenarios, refactoring should not be done."

Refactoring - Empirical Research

… =>
"The primary risk is regression, mostly from misunderstanding subtle corner cases in the original code and not accounting for them in the refactored code.” - dev.

"top 25% of refactored binaries have 12 percent more reduction in post-release defects compared to all modified binaries" - author

Refactoring - Empirical Research

“*An Empirical Investigation into the Impact of Refactoring on Regression Testing*” by Texas University =>

"The results on three open source projects, JMeter, XMLSecurity, and ANT, show that only 22% of refactored methods and fields are tested by existing regression tests."

Refactoring - Empirical Research

… =>

"The study found that test coverage of refactoring is insufficient and that regression tests are significantly impacted by refactorings edits..."

Demos

Tools

- Visual Studio Ultimate
  - code cloning
  - metrics
  - dependency graph
- FxCop
  - command line, rules...
- NDepend
  - all above + more

Tools - Choices

- **Visual Studio Ultimate**
  - **code cloning**
  - **metrics**
  - dependency graph
- FxCop
  - command line, rules...
- **NDepend**
  - **all above + more**

Conclusion

Incentives

Would incentivizing compliance lead to a better development process?

Maybe... No

Why?

Validity

Code analysis

- Fails to capture true complexity
- Is heavily correlated
- Helps enforce qualitative constraints

… in the end

Fundamentally, there is

- Breadth
- Depth

For a given requirements set

F(Breadth, Depth) == CONSTANT

Thanks

for patiently listening