Making an evolvable software: *Refactoring*

Dr. Ah-Rim Han

Today's Topic

- Software Engineering
- Refactoring
  - Why Need Refactoring?
  - What is Refactoring?
  - Refactoring Process
  - Bad Smells : Software Design Problems
  - Refactoring Types
  - Refactoring Assessment : Maintainability
    - Coupling and Cohesion metrics
  - Research Trends
- Doing Ph.D.

Software Engineering?

Definition

- IEEE's Standard 610.12-1990 : Glossary of Software Engineering Terminology
  - *Software engineering is defined as the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software*

Definition

- David Lorge Parnas
  - *Software engineering is defined as the multi-person construction of multi-version software*

In My Point of View…

- *Aims at providing the automated tools, techniques, processes to assist developers, managers, and stakeholders for systematic software development*

Needs Due to More

日 도요타 급가속 기술결함..美 법원 첫 평결
최종수정 2013.10.26 21:19기사입력 2013.10.26 21:19

도요타 또 추락 서울경제 | 2면2단 | 2014.04.09 (수) 오후 5:56
지난 2009~2010년 1,000만대 이상의 사상 최대 **리콜**사태를 겪었던 **도요타**가 올 2월 **소프트웨어** 문제로 하이브리드 모델 프리우스 190만대를 **리콜**한 데 이어 또다시 대규모 **리콜**을 실시하기로 함에 따라 소비자 신뢰에..
네이버에서 보기 | 관련기사 보기 | 이 언론사 내 검색

도요타 프리우스 190만대 **리콜** '**소프트웨어** 결함' tbs 교통방송 | 2014.02.12 (수) 오후 4:47
[tbs 고우리 기자] 미국에서 급발진 문제로 **리콜** 사태를 겪은 **도요타**자동차가 이번에는 하이브리드 승용차인 프리우스의 **소프트웨어** 결함으로 또다시 대규모 **리콜**을 결정했습니다. **리콜** 대상은 2009년 3월부터 올해 2월...
관련기사 보기 | 이 언론사 내 검색

도요타 또 **리콜**…639만대 규모 SBS CNBC | 2014.04.10 (목) 오전 8:25
도요타는 지난 2012년에도 740만대가 넘는 차량을 **리콜**했으며, 올해 2월에도 **소프트웨어**결함으로 190만대를 **리콜**한 바 있다. 전문가들은 이번 **리콜**로 **도요타**가 5억 8000만달러, 우리돈으로 약...
네이버에서 보기 | 관련기사 보기 | 이 언론사 내 검색

도요타, 27개 차종 676만대 **리콜**…사상 최대 규모 스포츠서울 | 2014.04.09 (수) 오후 4:39
또한 **도요타**는 지난 2월에도 하이브리드 승용차 프리우스 190만대를 **소프트웨어**(SW) 결함 문제로 **리콜**하기로 했다. **도요타**는 이로써 지난 2월 하이브리드 승용차 프리우스 190만 대를 **소프트웨어** 결함 문제로...
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도요타 639만대 **리콜**(회수·무상수리)… 세계 車 역사상 둘째로 큰 규모
조선일보 | B1면4단 | 2014.04.10 (목) 오전 3:06
도요타는 2012년에도 743만대를 **리콜**했었고, 올 2월에도 하이브리드 승용차 프리우스 190만대를 **소프트웨어**(SW) 결함으로 **리콜**한 바 있다. 포르테는 엔진 시동 모터가 과(過)회전해 발화(發火)의 우려가 있다는...
네이버에서 보기 | 관련기사 보기 | 이 언론사 내 검색

와 사측이 피해자와 합의했다.

소송에 영향을 미칠지 주목된다.

한 계기가 될 수 있다고 외신들은

다고 AP통신과 LA타임스 등이
다.

가 피해자들에게

않은 상태였다.

작 과실이거나 바닥 매트가 가속 페달을

하고 법정에 출석해 '복합적 **SW** 문제가

가능성은 작을 것으로 보인다.

른 격론이 적지 않았다고 LA타임스는

전했다.

이번 소송은 2007년 9월 진 북아웃이 몰던 캠리가 오클라호마주의 한 고속도로 출구에서 급발진하면서 일어난 사건에 관한 것이다.

차는 인근 장벽에 부딪쳐 운전자는 중상을 입었고 함께 차에 있던 승객 1명이 사망했다.

Refactoring

Why Need Refactoring?

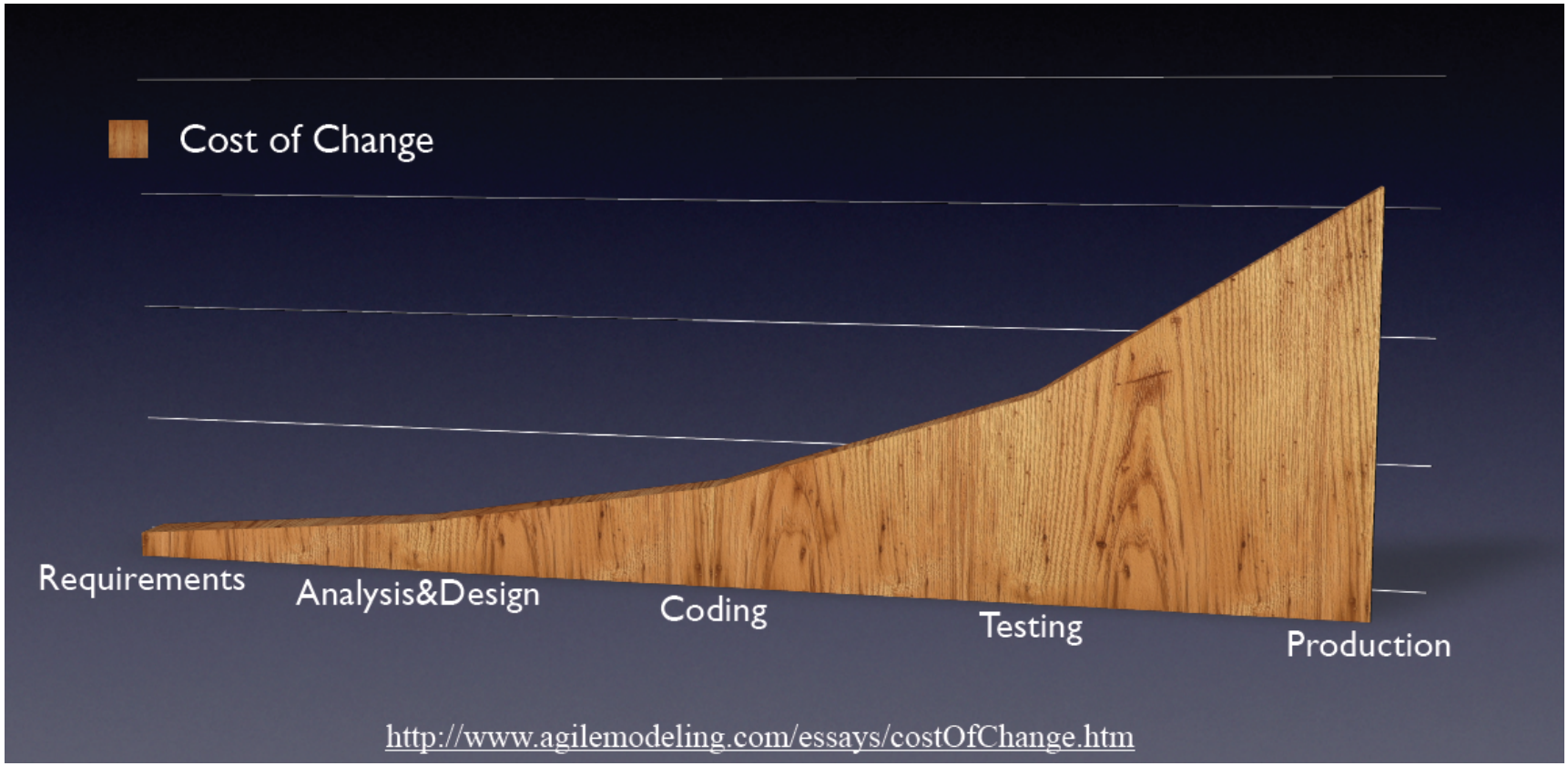
- Software changes
  - Introducing new functionalities
  - Correcting bugs
  - Adapting new environments
    - New OS, new hardware
  - Providing better qualities
    - Better performance, better reliability, …

→ Changes often take place without consideration of the design rationale due to time constraints

→ Therefore, the design quality of the software may degrade overtime

Why Need Refactoring?

- Cost of change curve



Why Need Refactoring?

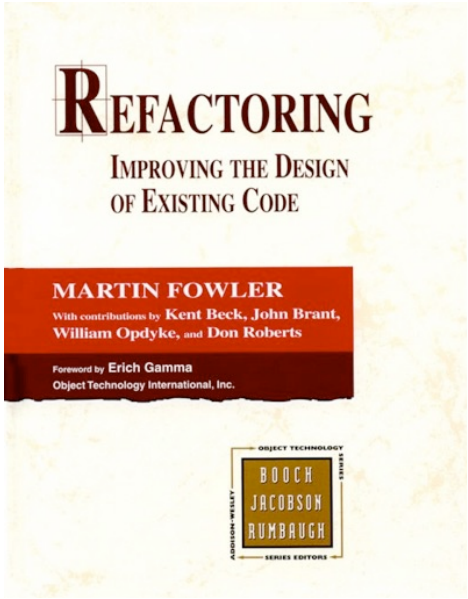
- Refactoring improves the design of software
- Refactoring makes software easier to understand
- Refactoring helps you program faster

→ These help to fix bugs and accommodating changes in a easier and faster way, which improves maintainability of the software

→ At the end, this reduces maintenance costs

What is Refactoring?

- What is refactoring?
  - *Refactoring (noun): a change made to the internal structure of software to make it easier to understand and cheaper to modify without changing its observable behavior*
  - *Refactor (verb): to restructure software by applying a series of refactorings without changing its observable behavior*



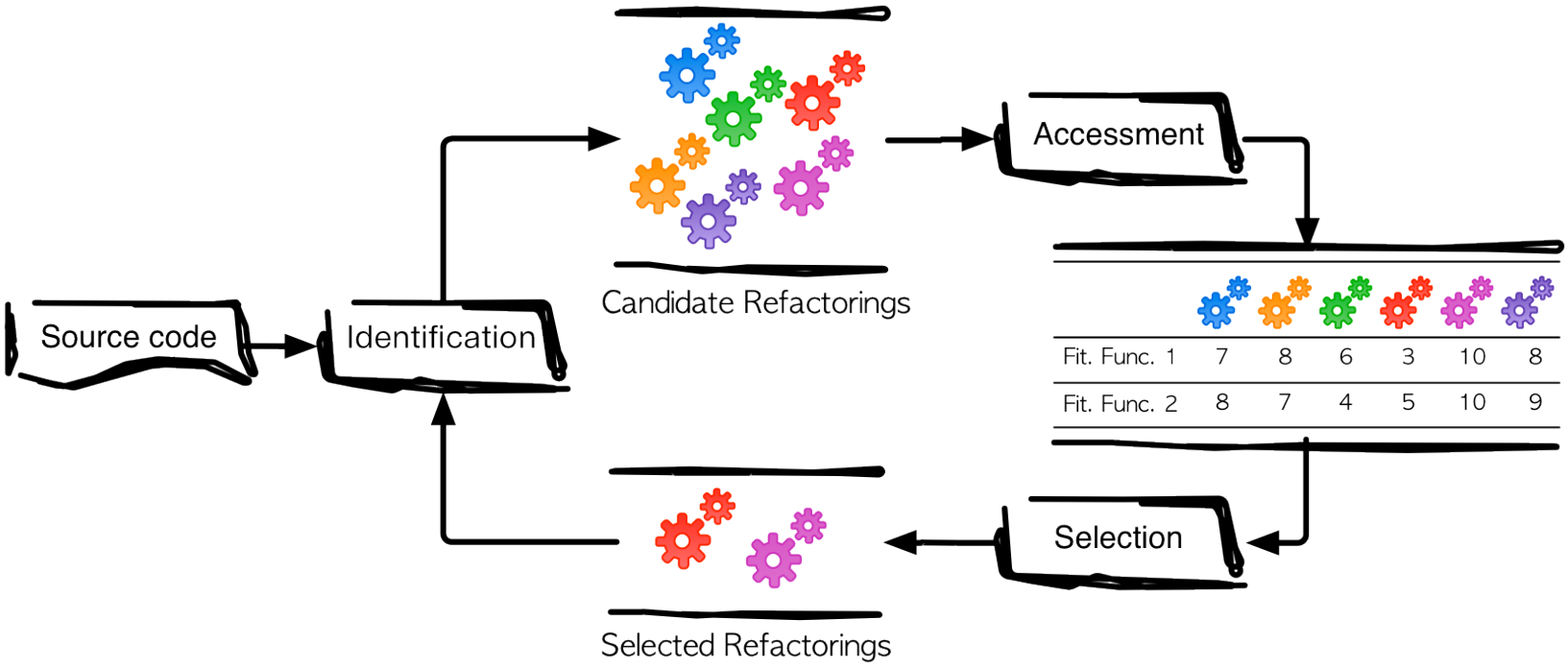
Martin Fowler's book: "Refactoring: Improving the Design of Existing Code", Addison Wesley, 1999

Refactoring Process

- Identify places where the software should be refactored
- Determine which refactoring(s) should be applied
- Guarantee that the applied refactoring preserves behavior
- Apply the refactoring
- Assess the effect of the refactoring on quality (e.g., maintainability, testability, understandability)
- Maintain the consistency between the refactored program code and other software artifacts

T. Mens, T. Tourwe, "A Survey of Software Refactoring", IEEE Transactions on Software Engineering (2004), pp. 126-139

Refactoring Process



Bad Smells

- Divergent Change
  - When one class is commonly changed in different ways for different reasons
  - Solution: Extract Class, Move Method

Bad Smells

- Shotgun Surgery
  - Is similar to divergent change but the opposite
    - Divergent change is one class that suffers many kinds of changes, and shotgun survey is one change that alters many classes
  - You have to make a lot of little changes to a lot of different classes
  - Solution: Move Method, Move Field, Inline Class
- Feature Envy
  - A method that seems more interested in a class other than the one it actually is in
  - Solution: Move Method

Refactoring Types

❖ Moving Features Between Objects

- Extract Class
- Hide Delegate
- Inline Class
- Introduce Foreign Method
- Introduce Local Extension
- Move Field
- Move Method
- Remove Middle Man

❖ Composing Methods

- Extract Method
- Inline Method
- Inline Temp
- Introduce Explaining Variable
- Remove Assignments to Parameters
- Replace Method with Method Object
- Replace Temp with Query
- Split Temporary Variable
- Substitute Algorithm

Refactoring Types

❖ Organizing Data

- Change Bidirectional Association to Unidirectional
- Change Reference to Value
- Change Unidirectional Association to Bidirectional
- Change Value to Reference
- Duplicate Observed Data
- Encapsulate Collection
- Encapsulate Field
- Replace Array with Object
- Replace Data Value with Object
- Replace Magic Number with Symbolic Constant
- Replace Record with Data Class
- Replace Subclass with Fields
- Replace Type Code with Class
- Replace Type Code with State/Strategy
- Replace Type Code with Subclasses
- Self Encapsulate Field

Refactoring Types

❖ Simplifying Conditional Expressions

- Consolidate Conditional Expression
- Consolidate Duplicate Conditional Fragments
- Decompose Conditional
- Introduce Assertion
- Introduce Null Object
- Remove Control Flag
- Replace Conditional with Polymorphism
- Replace Nested Conditional with Guard Clauses

❖ Dealing with Generalization

- Collapse Hierarchy
- Extract Interface
- Extract Subclass
- Extract Superclass
- Form Template Method
- Pull Up Constructor Body
- Pull Up Field
- Pull Up Method
- Push Down Field
- Push Down Method
- Replace Delegation with Inheritance
- Replace Inheritance with Delegation

Refactoring Types

Making Method Calls Simpler

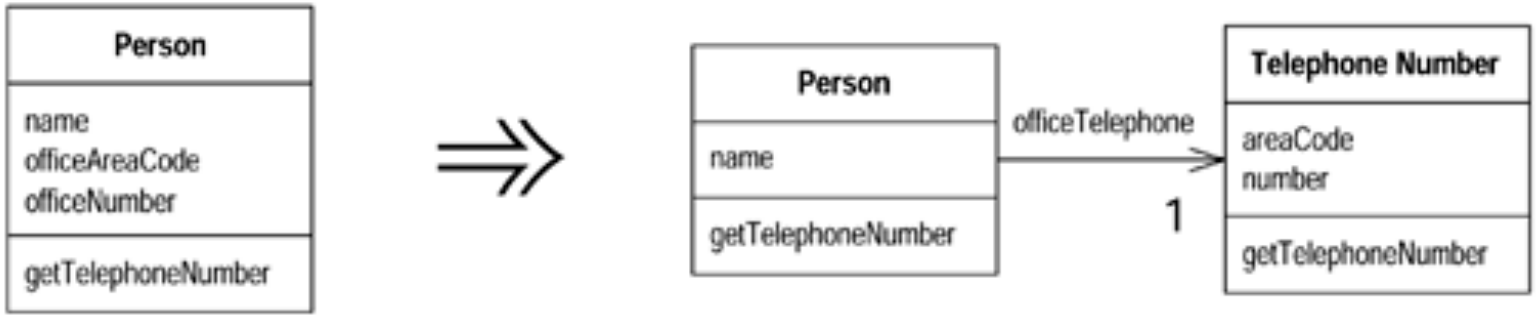
- Add Parameter
- Encapsulate Downcast
- Hide Method
- Introduce Parameter Object
- Parameterize Method
- Preserve Whole Object
- Remove Parameter
- Remove Setting Method
- Rename Method
- Replace Constructor with Factory Method
- Replace Error Code with Exception
- Replace Exception with Test
- Replace Parameter with Explicit Methods
- Replace Parameter with Method
- Separate Query from Modifier

Big Refactorings

- Convert Procedural Design to Objects
- Extract Hierarchy
- Separate Domain from Presentation
- Tease Apart Inheritance
- The Nature of the Game

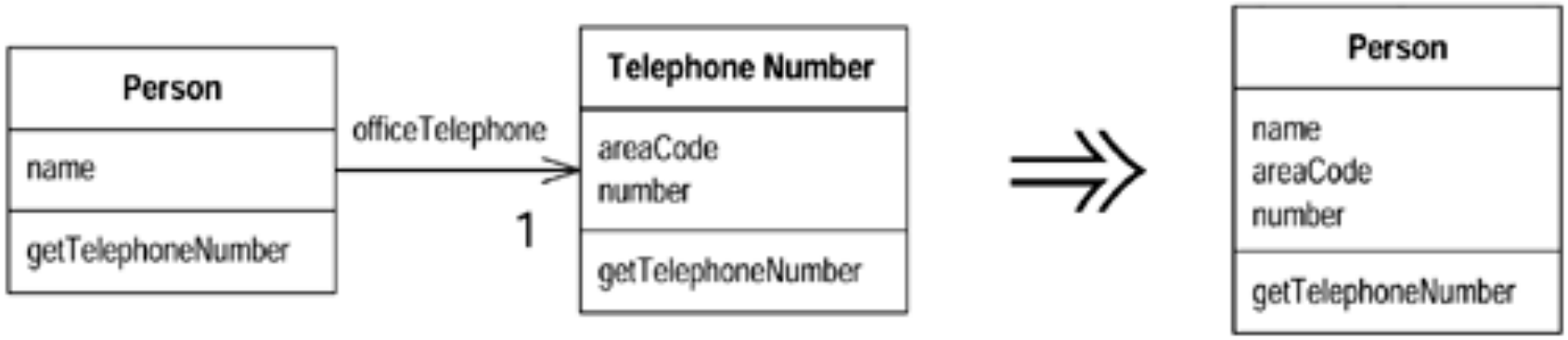
Refactoring Types

- Extract Class
  - You have one class doing work that should be done by two
  - → *Create a new class and move the relevant fields and methods from the old class into the new class*



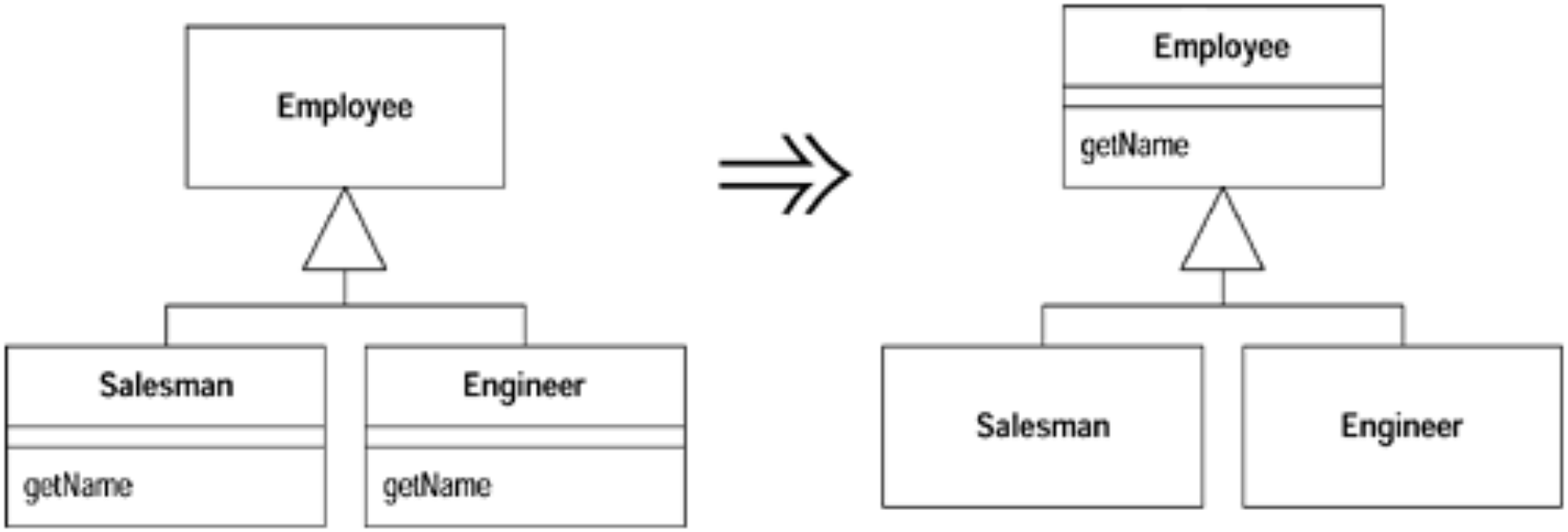
Refactoring Types

- Inline Class
  - A class isn't doing very much.
  - → *Move all its features into another class and delete it.*



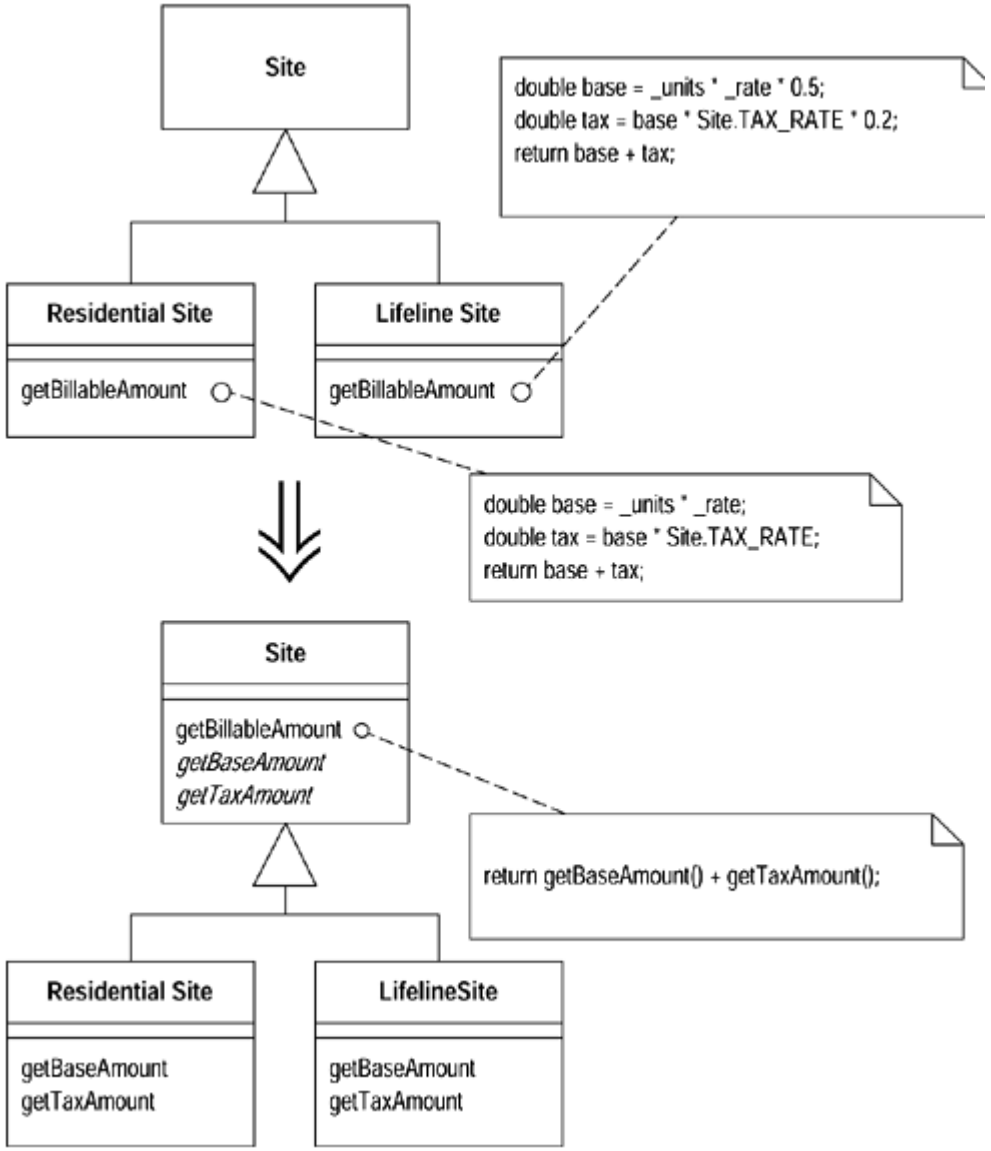
Refactoring Types

- Pull Up Method
  - You have methods with identical results on subclasses.
  - → *Move them to the superclass.*



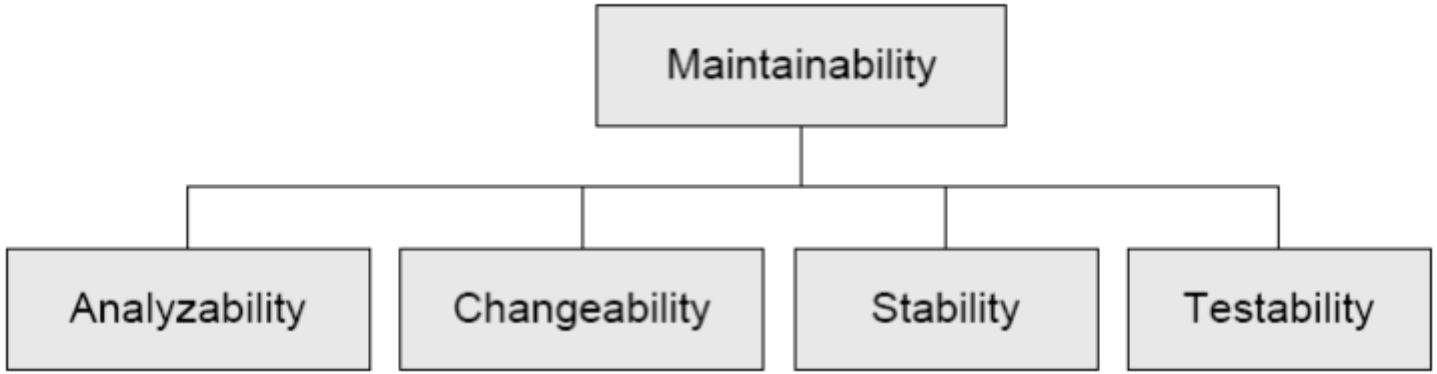
Refactoring Types

- Form Template Meth
  - You have two metho similar steps in the s different.
  - → *Get the steps into so that the original m you can pull them up*



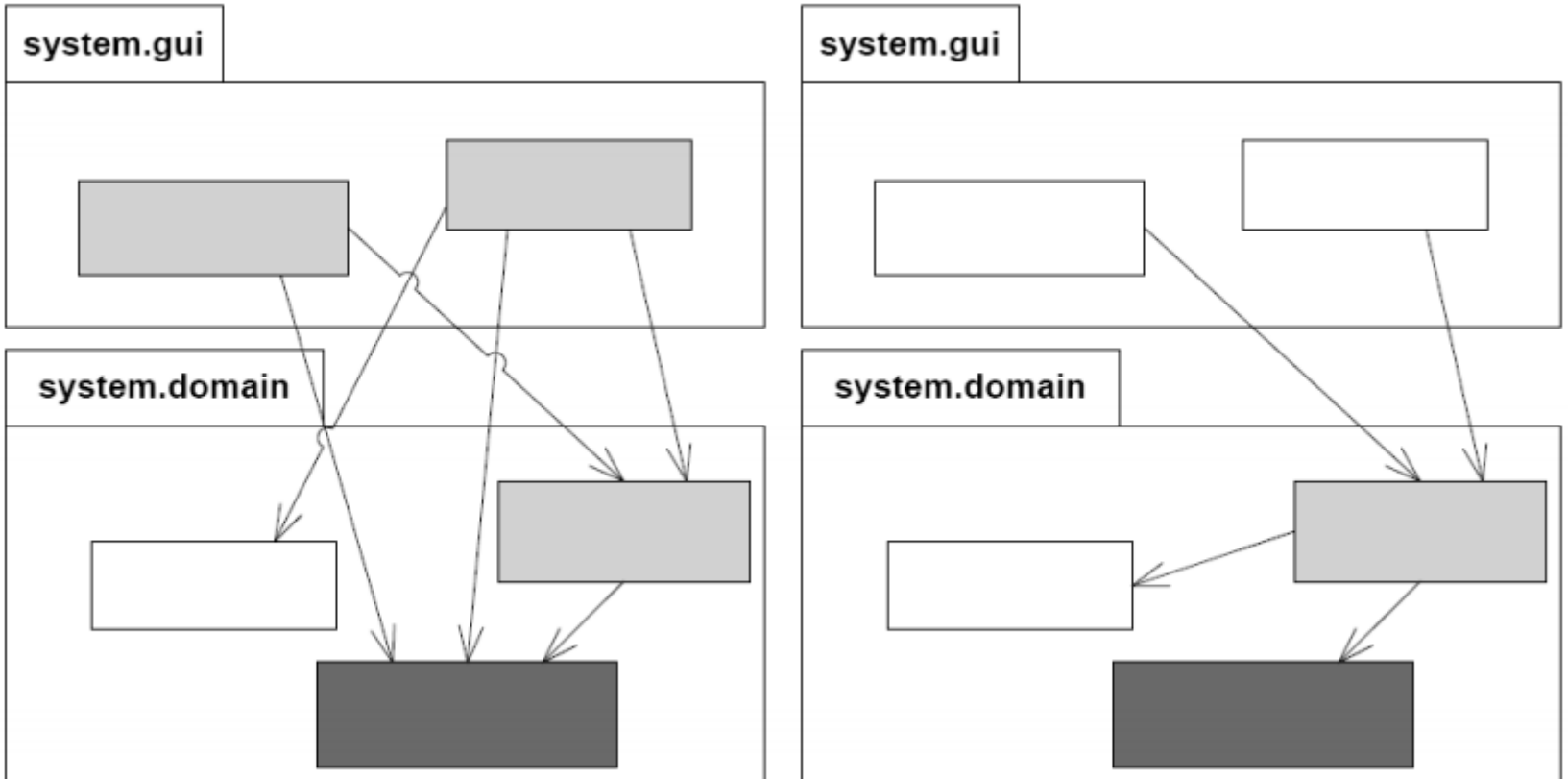
Refactoring Assessment

- Maintainability
  - Definition (from ISO 9126)
    - The capability of the software product to be modified.
    - Modifications may include corrections, improvements or adaptation of the software to changes in environment, and in requirements and functional specification
  - Maintainability is influenced by a lot of sub-qualities



Refactoring Assessment

- Coupling
  - a measure of how strongly dependent one software unit is on other software units
    - unit = class, package, module, method, application, etc.



Refactoring Assessment

- Cohesion
  - a measure of how strongly related and focused the responsibilities and provided behavior of a software unit are

→ Good design = high maintainability
low coupling and high cohesion

Cohesion Metrics

- Method Similarity Cohesion (MSC) [0]

$$MSC(C) = \frac{2}{n(n-1)} \sum_{i=1}^{\frac{n(n-1)}{2}} \frac{IV_c}{IV_t} i,$$

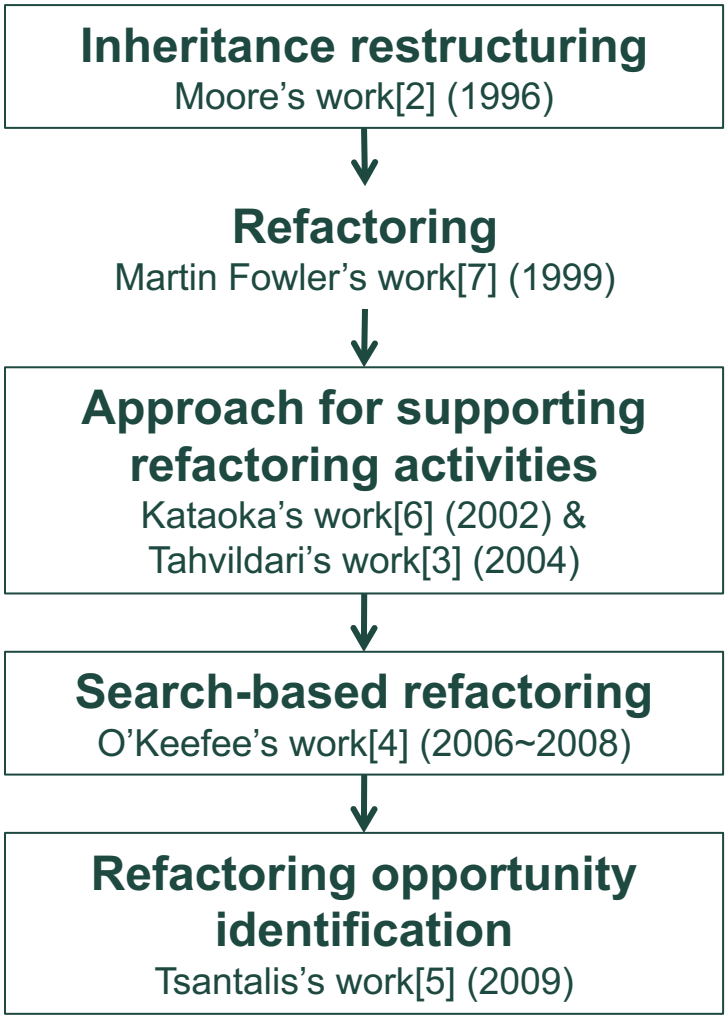
where class C has n methods, and for a pair of methods, IV_c and IV_t stand for the common (i.e., intersect set) and total instance (i.e., union set) variables used by the pair of methods repeatedly. Since there are $\frac{n(n-1)}{2}$ distinct combinations of pairs of methods in a class, i ranges from 1 (i.e., first pair) to $\frac{n(n-1)}{2}$ (i.e., last pair), and $\frac{|IV|_c}{|IV|_t} i$ indicates the similarity of the pair of methods, respectively.

- Lack of Cohesion in Methods (LCOM) [1]
- Cohesion Among Methods in Class (CAMC) [2]

Coupling Metrics

- Message Passing Coupling (MPC) [3]
  - Counts static method calls for all invoked methods in the import direction
- Request For a Class (RFC) [1]
  - Counts static method calls for distinct methods in the import direction
- Coupling Between Objects (CBO) [1]
  - Counts static method calls for distinct methods in both directions.
- Coupling Factor (CF) [4]
  - The coarse-grained metrics / measured based on the number of coupled classes, not on the methods

Research Trends



- Focus on implementation issues (e.g., maximizing sharing and minimizing duplication at method or expression level)
- Start to focus on improving software design quality; therefore, consider higher levels such as methods and classes
- Provide methods such as
  - Design flaw detection (or bad smell detection)
  - Evaluation of refactoring effect on design quality
  - Program behavior preservation, etc.
- Want to automate the full refactoring process (without human intervention) by treating OO design as an optimization problem
- Provide the method for automated identification (i.e., suggestion) of specific refactoring opportunities to resolve specific design problems or to improve specific design quality (which does not depend on random choice)

Doing Ph.D.

Life in the laboratory

seminar

topics in th

nces

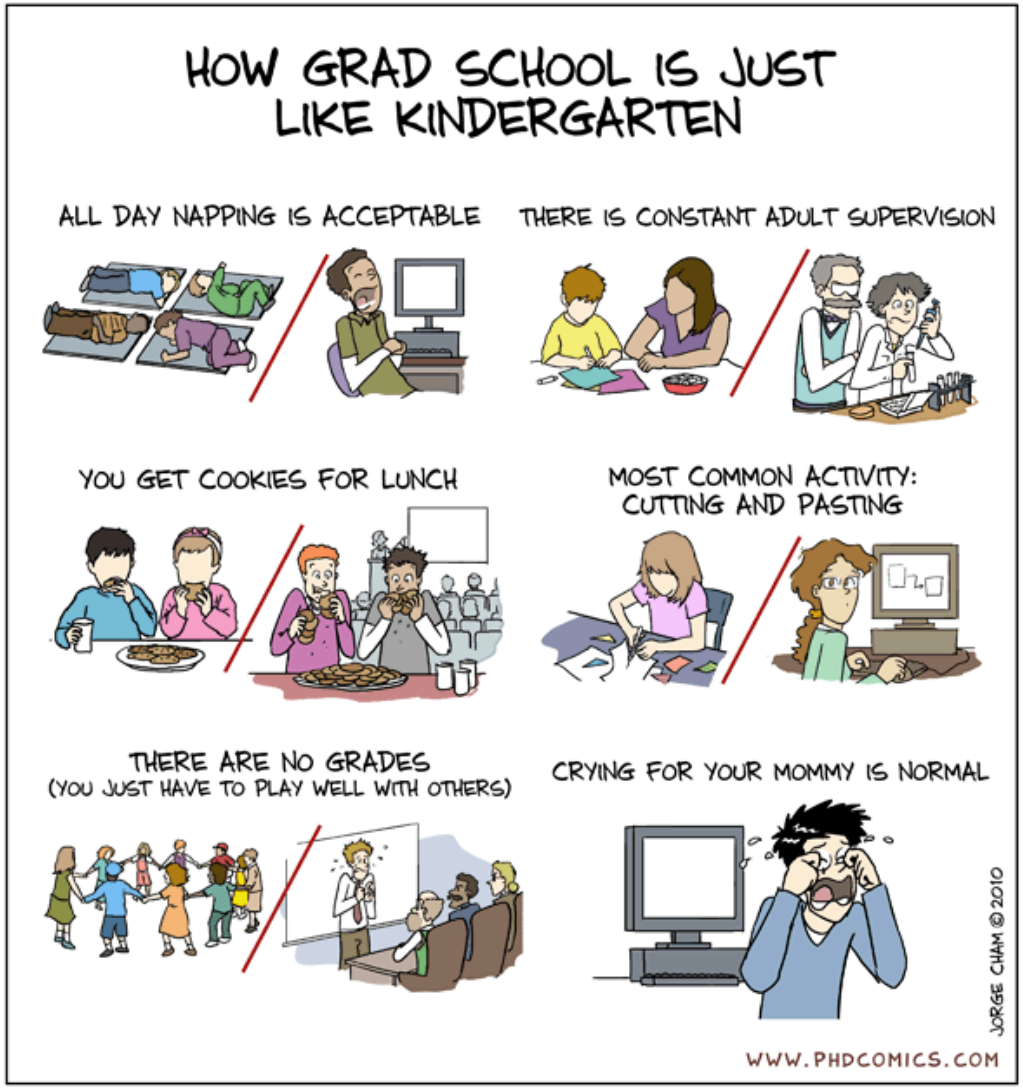
International Conference on Software Engineering (2006)

Korea Computer Congress (KCC)

Korean Conference on Software Engineering

Asia Pacific Conference on Software Engineering (2013)

How Hard… But, It's Worth!!!



Qualification to be Succeed in Ph.D

- Fundamental basis
  - Algorithm, data base, automata, system programming, compiler, graphics, artificial intelligence, network, operating systems, computer architecture, stochastic, …
- English skills (presentation, discussion, writing a paper, …)
- Communication skills
- Self-motivated

References

- Lecture notes from Dr. Miryung Kim
  - http://users.ece.utexas.edu/~miryung/teaching/EE461L-Fall2013/main.html
- Lecture notes
  - http://kurser.lobner.dk/dSoftArk/Slides/w44-45/4_3_maintainability.pdf
- Refactoring materials:
  - http://sourcemaking.com/refactoring
- Martin Fowler's book: "Refactoring: Improving the Design of Existing Code", Addison Wesley, 1999
  - http://martinfowler.com/refactoring/

- [0] C. Bonja, E. Kidanmariam, Metrics for class cohesion and similarity between methods, in: Proceedings of the 44th Annual Southeast Regional Conference, 2006, pp. 91–95.
- [1] S. Chidamber, C. Kemerer, A metrics suite for object oriented design, IEEE Transactions on Software Engineering 20 (1994) 476–493.
- [2] J. Bansiya, L. Etzkorn, C. Davis, W. Li, A class cohesion metric for objectoriented designs, journal of object-oriented program, Journal of Object-Oriented Program 11 (1999) 47–52.
- [3] W. Li, S. Henry, Object-oriented metrics that predict maintainability, Journal of Systems and Software 23 (1993) 111–122.
- [4] L. Briand, J. Daly, J. Wust, A unified framework for coupling measurement in object-oriented systems, IEEE Transactions on Software Engineering 25 (1999) 91–121.