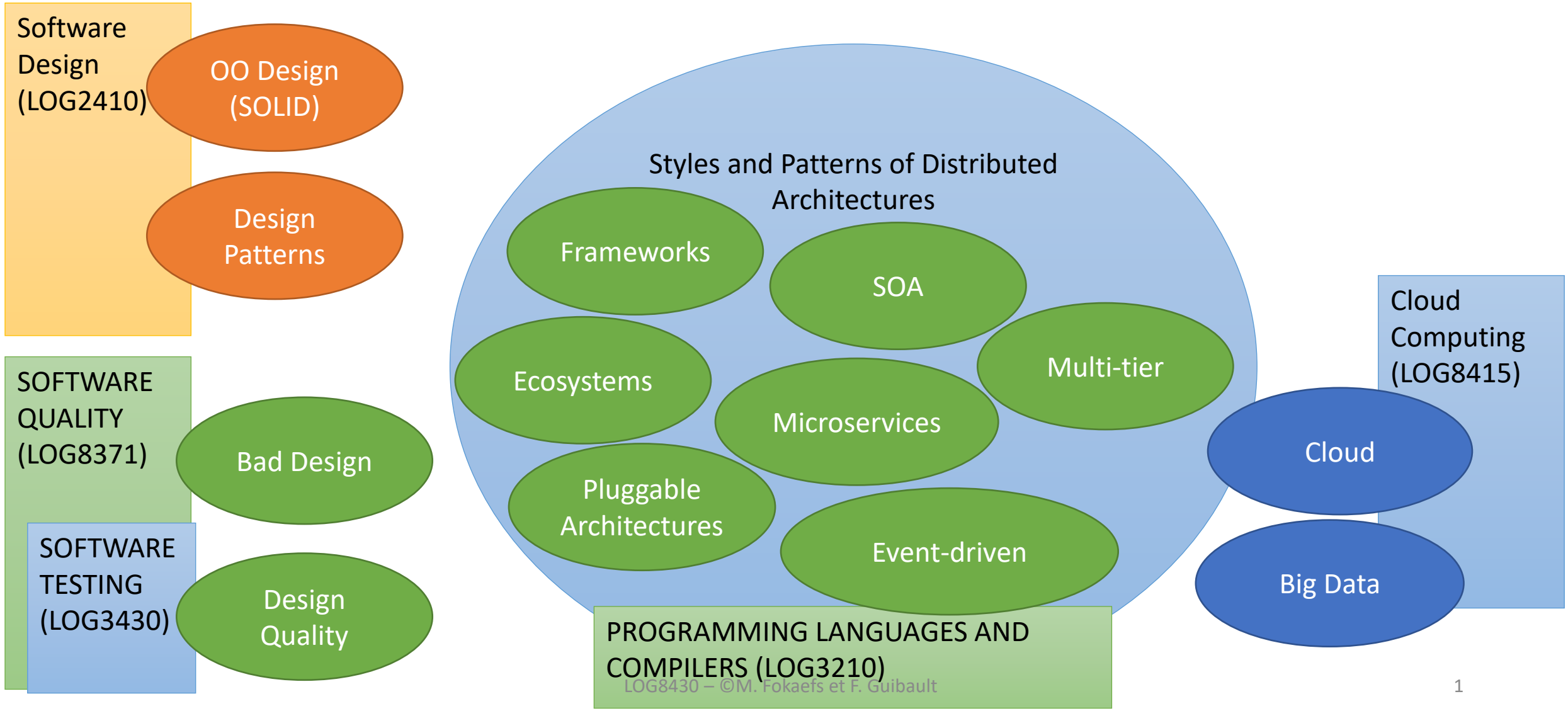
Course Map


Software Design (LOG2410)
OO Design (SOLID)
Design Patterns
SOFTWARE QUALITY (LOG8371)
Bad Design
SOFTWARE TESTING (LOG3430)
Design Quality
Styles and Patterns of Distributed Architectures
Frameworks
SOA
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Multi-tier
Microservices
Pluggable Architectures
Event-driven
PROGRAMMING LANGUAGES AND COMPILERS (LOG3210)
Cloud Computing (LOG8415)
Cloud
Big Data

POLYTECHNIQUE MONTRÉAL
UNIVERSITÉ D'INGÉNIERIE

LOG8430E: Bad Design

Fall 2020

Today

LOG2410

OO Design (SOLID)

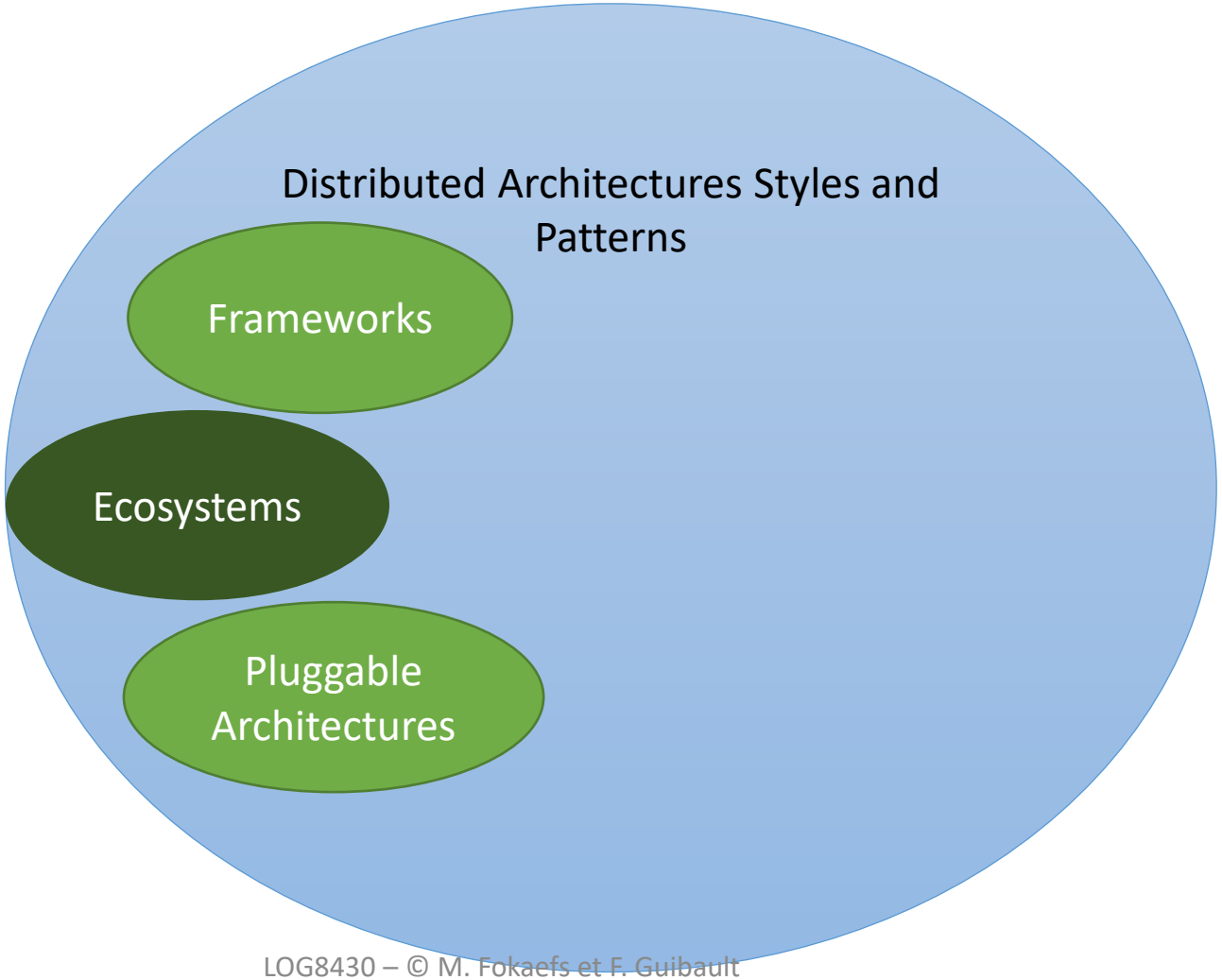
Design Patterns

LOG8371

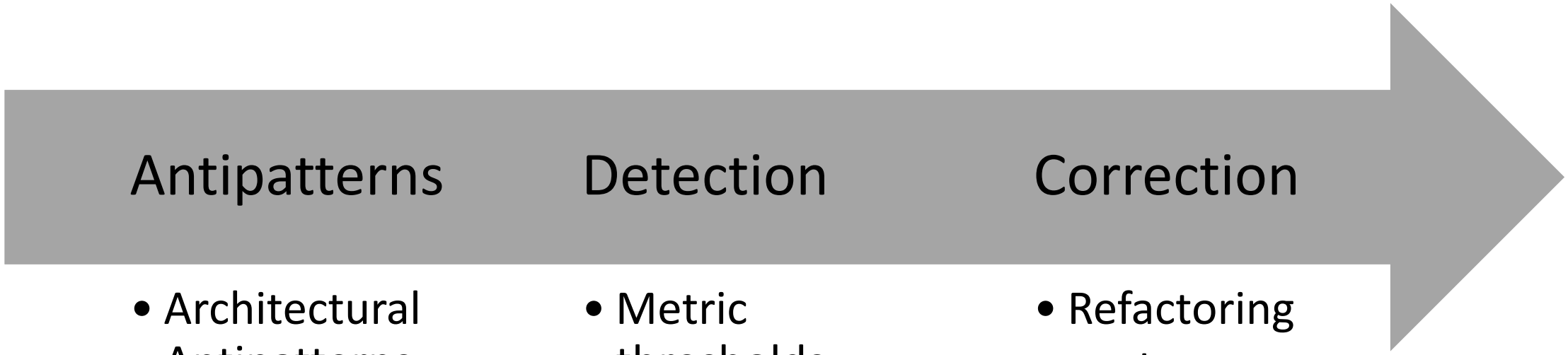
Bad Design

LOG3430

Design Quality



Agenda



- Architectural Antipatterns
- Design Antipatterns
- Code Antipatterns

- Metric thresholds
- Detection Strategies

- Refactoring
- Tools (JDeodorant, Eclipse

What is an antipattern?

- A pattern is a solution to a recurring problem and which facilitates the activities that are peripheral to the development, like maintenance, quality assurance and others.
  - It is a good practice!
- An antipattern is a solution to a recurring problem, but which is often insufficient and counterproductive.
  - It’s a bad practice!
- But why do antipatterns exist?
  - Inability or insufficient ability
  - Good short-term solutions but with harmful long-term consequences .
  - Use of good patterns in an inappropriate context.

Architectural antipatterns

- Architecture by implication
- Autogenerated Stovepipe
- Cover your Assets
- Design by Committee
- Jumble
- Reinvent the Wheel
- Spaghetti Code
- Stovepipe System
- Swiss Army Knife
- Vendor Lock-in

Architecture by Implication

- Definition
  - The architects have a lot of experience in developing similar system and they do not prepare sufficient architectural specifications.
- Symptoms and Consequences
  - A lack of planning and specification of architecture.
  - Ignorance concerning new technologies
  - Hidden risks that emerge during the project: lack of domain knowledge, technologies and unexpected complexity.
  - Imminent failure
- Causes
  - Absence of risk management
  - Excessive confidence from managers, architects and developers.
  - Dependence to previous experiences that differ under certain critical aspects.
  - Non-resolved architectural issues or implicit causes from deficiencies in engineering the system.

Architecture by Implication

- Refactoring
  - Modularize the architecture specification in views and in points of view.
  - Each view represents a stakeholder (architect, developer, client, etc.)
  - Express the architecture in terms of goals and questions (GQA): goals, questions, views, analysis of views, integration of views, matching between views and requirements, refinement of views, communication of the architecture, validation of the implementation.
- Exceptions
  - If the differences between two projects are small, few and local.
  - For an exploratory project.

Autogenerated Stovepipe

- Definition
  - The problem occurs when we migrate a system to a distributed version.
  - The interfaces of the original system may be inappropriate for the distributed system.
  - The local operations often make various assumptions over the placement, e.g., the access to the local file system.
- Refactoring
  - Define the distributed interfaces from scratch (using the façade pattern?).
  - The interoperability and the stability must be of the highest priority.

Cover your assets

- Definition
  - The documentation is very detailed to cover all options and all exceptions, which makes it very complicated.
- Refactoring
  - Use abstractions, like diagrams and tables, to communicate the architecture in a more efficient manner.

Design by committee

- Definition
  - All the team members can influence the decisions for the architecture and the design. The result is a very complex documentation with all the possible characteristics.
- Symptoms and consequences
  - Frequent meetings, but not organized and without objective.
  - A lot of conflicts among architects and developers.
  - A lot of effort to interpret and develop the specifications.
- Causes
  - The roles are not well-defined.
  - An effort to satisfy everyone.
  - Long but not organized meetings.

Design by committee

- Refactoring
  - Define clear roles for the team members.
  - Designate a principal architect for the project, who will make the final decisions.
  - Prioritize the requirements.
  - Organize the meetings and reduce their duration.
  - Possibly divide the teams to better organize the meetings (DevOps).
- Exceptions
  - When the teams are small.

Jumble

- Definition
  - When the horizontal elements merge with the vertical elements. The horizontal elements are the layers of a general architecture. The vertical elements are the architecture tiers specific to an application. (Like a DIP violation).
- Symptoms and consequences
  - Reduced reusability and stability.
- Causes
  - Lack of communication between the developers and the architects.
- Refactoring
  - Treat the horizontal elements as abstractions and the vertical elements as implementations.
  - Add vertical elements for special functionalities or for performance.

Reinvent the Wheel

- Definition
  - When a system is designed from scratch. The existing examples and architectures are not considered.
- Symptoms and consequences
  - The reusability and interoperability are reduced. The effort is increased.
  - Closed architectures, relevant only to one specific system (like a violation of OCP).
  - Useless replication of existing designs.
- Causes
  - “Greenfield Assumptions”: the system needs to be designed from scratch. We are the first to do something like this.
  - Insufficient knowledge of other projects.

Reinvent the Wheel

- Refactoring
  - Mine architectures to identify relevant examples.
  - Put in place a spiral, agile or iterative software process.
  - Refine the requirements and the design decisions, and identify the architecture prototypes in other systems.
- Exceptions
  - When the communication is difficult and we want to minimize the coordination costs.

Spaghetti Code

- Definition
  - The software lacks structure and coherence.
  - “The problem with visual programming is that spaghetti code really looks like spaghetti!”
- Symptoms and consequences
  - The understandability and the reusability are reduced.
  - The system is more procedural than object-oriented.
  - Maintenance effort is increased.
- Causes
  - Lack of experience.
- Refactoring
  - Refactoring
  - Use of patterns and good design practices.
- Exceptions
  - Spaghetti code can be tolerated when it exists in the implementation but not in the public interfaces.

Stovepipe System

- Definition
  - The antipattern occurs when we want to integrate subsystems. Each integration is special and there isn't a general integration plan for the entire system.
- Symptoms and consequences
  - Maintainability and interoperability are reduced.
  - The implementation does not correspond to the documentation.
  - The system becomes too complicated.
  - Portability is reduced.
- Causes
  - Lack of abstraction. The interface of each subsystem is unique.
  - High coupling.
  - Lack of a central architecture.
- Refactoring
  - Define a common interface (SOA).

Swiss Army Knife

- Definition
  - A very complicated interface that exposes many functionalities (a violation of SRP and of ISP).
- Refactoring
  - Refactoring! (Extract an interface or a class).
  - Use the adapter or façade pattern.
  - Document the use and the implementation of an interface. Create a profile.

Vendor Lock-in

- Definition
  - When the system depends directly on proprietary software or hardware.
- Symptoms and consequences
  - The upgrades of commercial products drive the maintenance cycle of applications.
  - Failures in the applications occur due to delays induced by commercial products.
  - Violations of DIP and of OCP.
  - Portability is reduced.
- Causes
  - There is no universal standard.
  - The commercial product does not conform to open standards.
  - Choice of products for economic but not technical reasons.
- Refactoring
  - Multitier architecture
  - Use of abstractions

Design antipatterns

- Missing abstraction
- Multifaceted abstraction
- Duplicate abstraction
- Deficient encapsulation
- Unexploited encapsulation
- Broken modularization
- Insufficient modularization
- Cyclically-dependent modularization
- Unfactored hierarchy
- Broken hierarchy
- Cyclic hierarchy

Missing abstraction

- Definition
  - When groups of cohesive data often exist together in the context of a larger module.
  - E.g., `telephoneNumber, areaCode, countryCode`
- Symptoms and consequences
  - Violation of SRP
  - Increased complexity
  - Reduced maintainability and understandability.
- Refactoring
  - Extract a class.

Multifaceted abstraction

- Definition
  - An abstraction has more than one responsibility
- Symptoms and consequences
  - Violation of SRP.
- Refactoring
  - Extract a class or a superclass.

Duplicate abstraction

- Definition
  - Two abstractions have the same name or the same implementation (cloning).
  - Note: The same name is allowed between two classes as long as they belong in different packages.
- Causes
  - Copy-paste
  - Lack of communication
- Refactoring
  - Extract class or superclass

Deficient encapsulation

- Definition
  - When an abstraction gives more permissions than necessary, e.g., when all the attributes are declared as public.
- Symptoms and consequences
  - Maintainability and security are reduced.
- Causes
  - Procedural thinking in an object-oriented context.
  - Negligent maintenance.
  - To facilitate tests.
- Refactoring
  - Encapsulate data and provide access methods.

Unexploited encapsulation

- Definition
  - The use of explicit type verification when polymorphism is available.
- Symptoms and consequences
  - Increased complexity.
  - Reduced maintainability and understandability.
- Causes
  - Procedural thinking in an object-oriented context.
  - Failure of applying object-oriented principles.
- Refactoring
  - Replace type checking with polymorphism.

Broken modularization

- Definition
  - Data or methods that should be together, with respect to semantic similarity or usage, belong to many abstractions.
- Symptoms and consequences
  - High coupling, low cohesion.
  - Reduced maintainability.
  - The performance deteriorates.
- Causes
  - Procedural thinking in an object-oriented context.
  - Lack of knowledge of the existing design.
- Refactoring
  - Move methods or attributes
  - Inline class

Insufficient modularization

- Definition
  - An abstraction that has many public attributes and too complex methods.
- Symptoms and consequences
  - Violation of SRP and of ISP.
- Causes
  - Centralized control.
- Refactoring
  - Extract class or interface

Cyclically-dependent modularization

- Definition
  - Two abstractions use many members of each other.
- Symptoms and consequences
  - High coupling.
- Causes
  - Passing “this” pointer.
  - The abstraction is not designed correctly.
- Refactoring
  - Move methods or attributes.
  - Inline class.

Unfactored hierarchy

- Definition
  - In a hierarchy, there is duplication between the derived classes or between the derived classes and the base class.
- Symptoms and consequences
  - Maintainability is reduced.
- Causes
  - Code duplication (cloning)
  - Copy-paste
- Refactoring
  - Extract superclass
  - Pull up methods or attributes

Broken hierarchy

- Definition
  - The base class and the derived class do not have a “is-a” relationship.
- Symptoms and consequences
  - Violation of LSP.
- Causes
  - The inheritance is introduced for implementation purposes and not for design.
- Refactoring
  - Replace inheritance with delegation.
  - Invert the inheritance relationship.

Cyclic hierarchy

- Definition
  - A base class has an association with one or more of the derived classes.
- Symptoms and consequences
  - High coupling.
  - Reduced understandability
- Causes
  - Inheritance is not correctly designed.
- Refactoring
  - Extract class.
  - Move methods
  - Inline class
  - Implement a State or a Strategy pattern.

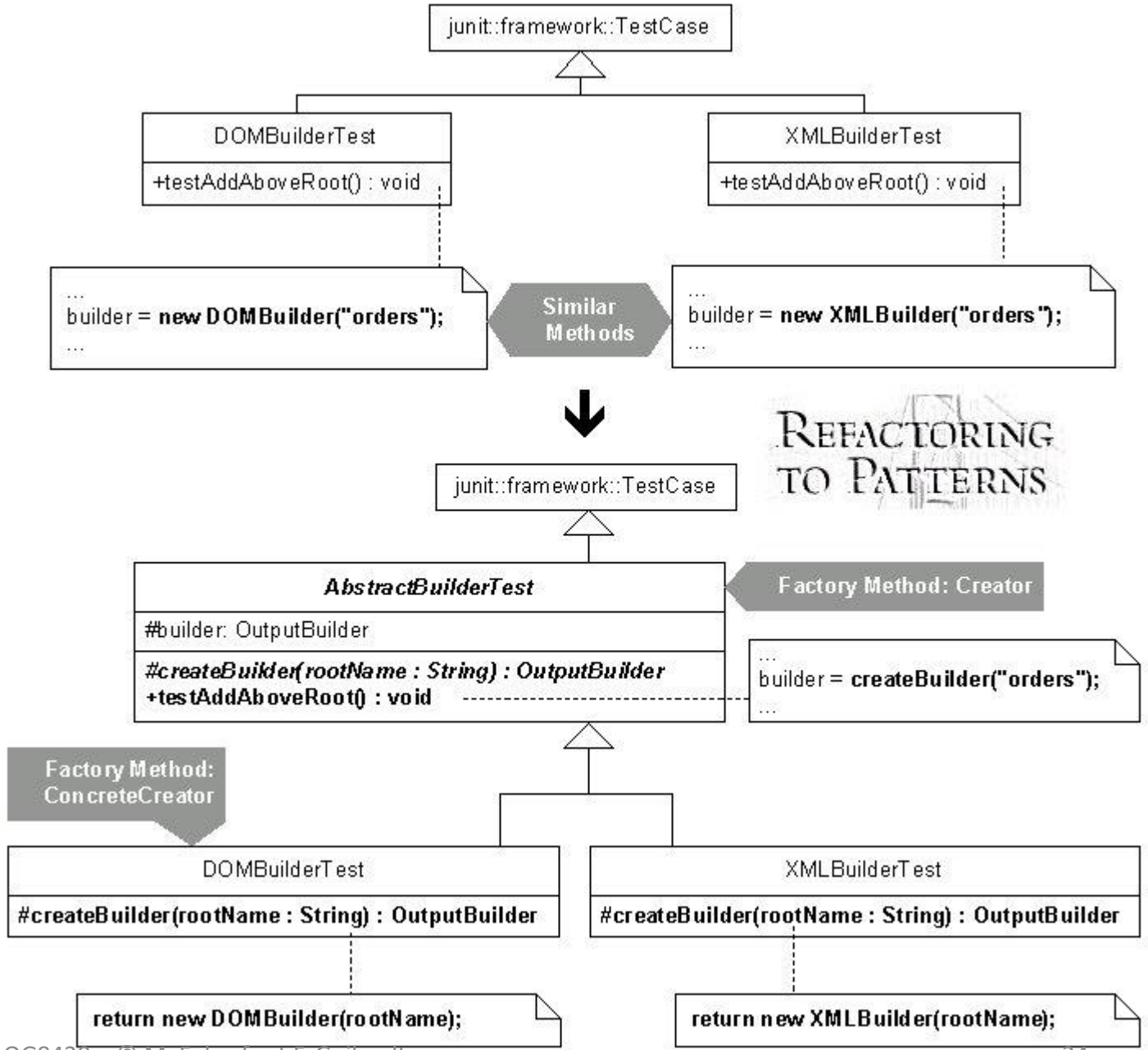
Code antipatterns

- Duplicated Code
- Long Method
- Large Class
- Long Parameter List
- Divergent Change
- Shotgun Surgery
- Feature Envy
- Switch Statements
- Message Chains
- Inappropriate Intimacy
- Refused Bequest

Duplicated Code

- Definition
  - The same code exists in multiple places in the system.
- Refactoring
  - Extract method
  - Construct a generic class
  - Extract class
  - Chain constructors
  - Introduce a polymorphic object creation method using the Factory Method design pattern.

Introduce Polymorphic Creation with Factory Method



Long Method

- Definition
  - A method has a long implementation that does a lot of things
- Refactoring
  - Extract method
  - Decompose conditional statements
  - Compose method

Compose Method

```
public void add(Object element) {
  if (readOnly) {
    int newSize = size + 1;
    if (newSize > elements.length) {
      Object[] newElements =
        new Object[elements.length + 10];
      for (int i = 0; i < size; i++)
        newElements[i] = elements[i];
      elements = newElements;
    }
    elements[size++] = element;
  }
}
```

```
public void add(Object element) {
  if (readOnly)
    return;
  if (atCapacity())
    grow();
  addElement(element);
}
```

Large Class

- Definition
  - A class that has a lot of members or a lot of responsibilities
- Refactoring
  - Extract class
  - Extract superclass
  - Extract subclass

Long Parameter List

- Definition
  - A method has a long list of parameters.
- Refactoring
  - Replace parameters with method
  - Introduce parameter object

Divergent Change

- Definition
  - A class changes a lot, many times, or every time there is a change in the requirements.
- Refactoring
  - Extract class

Shotgun Surgery

- Definition
  - When there is a change, we need to change the code in many places.
- Refactoring
  - Move methods
  - Inline class

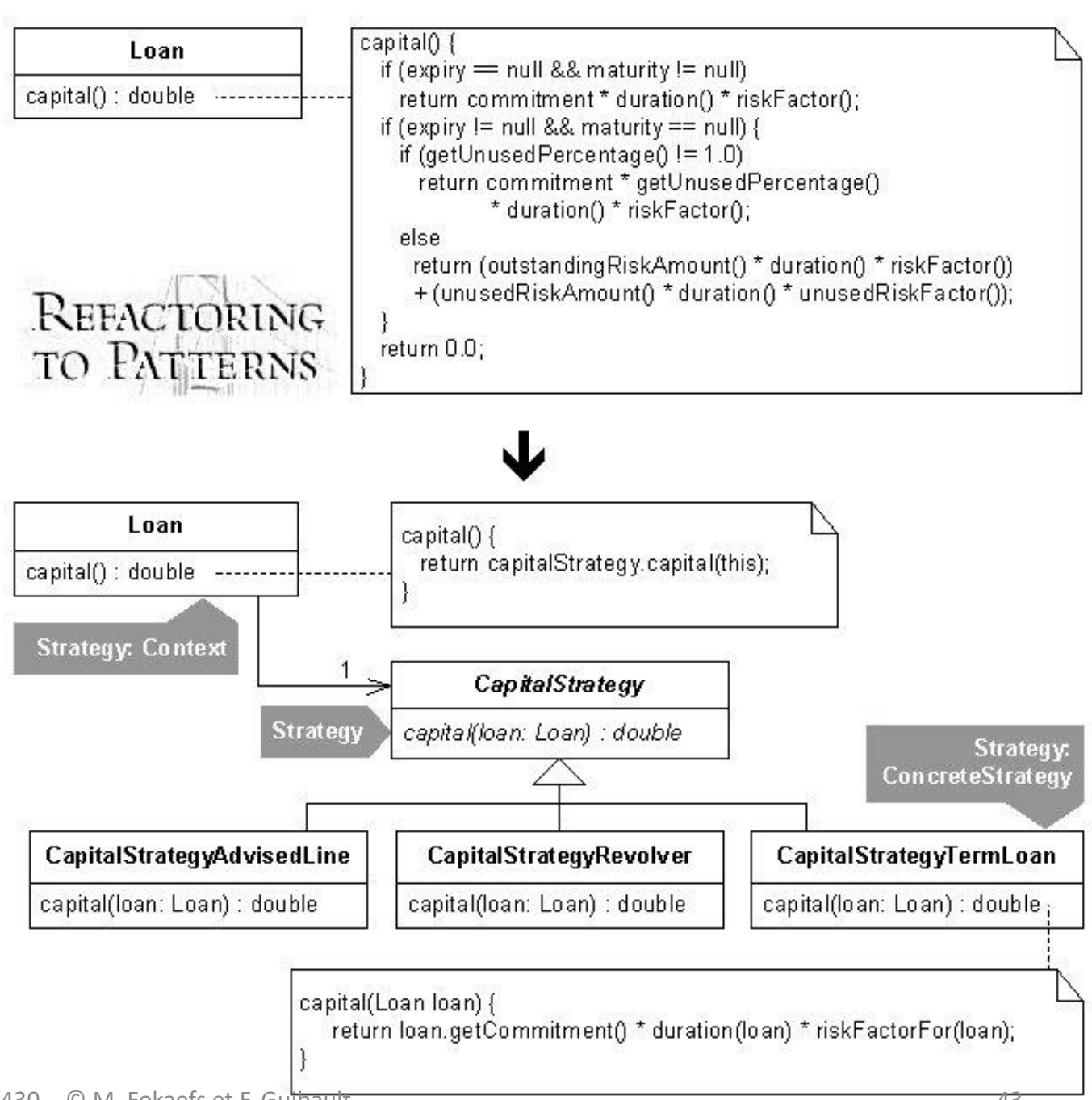
Feature Envy

- Definition
  - A method uses more members from other classes than from the class it belongs to.
- Refactoring
  - Move method
  - Extract or move methods or attributes.

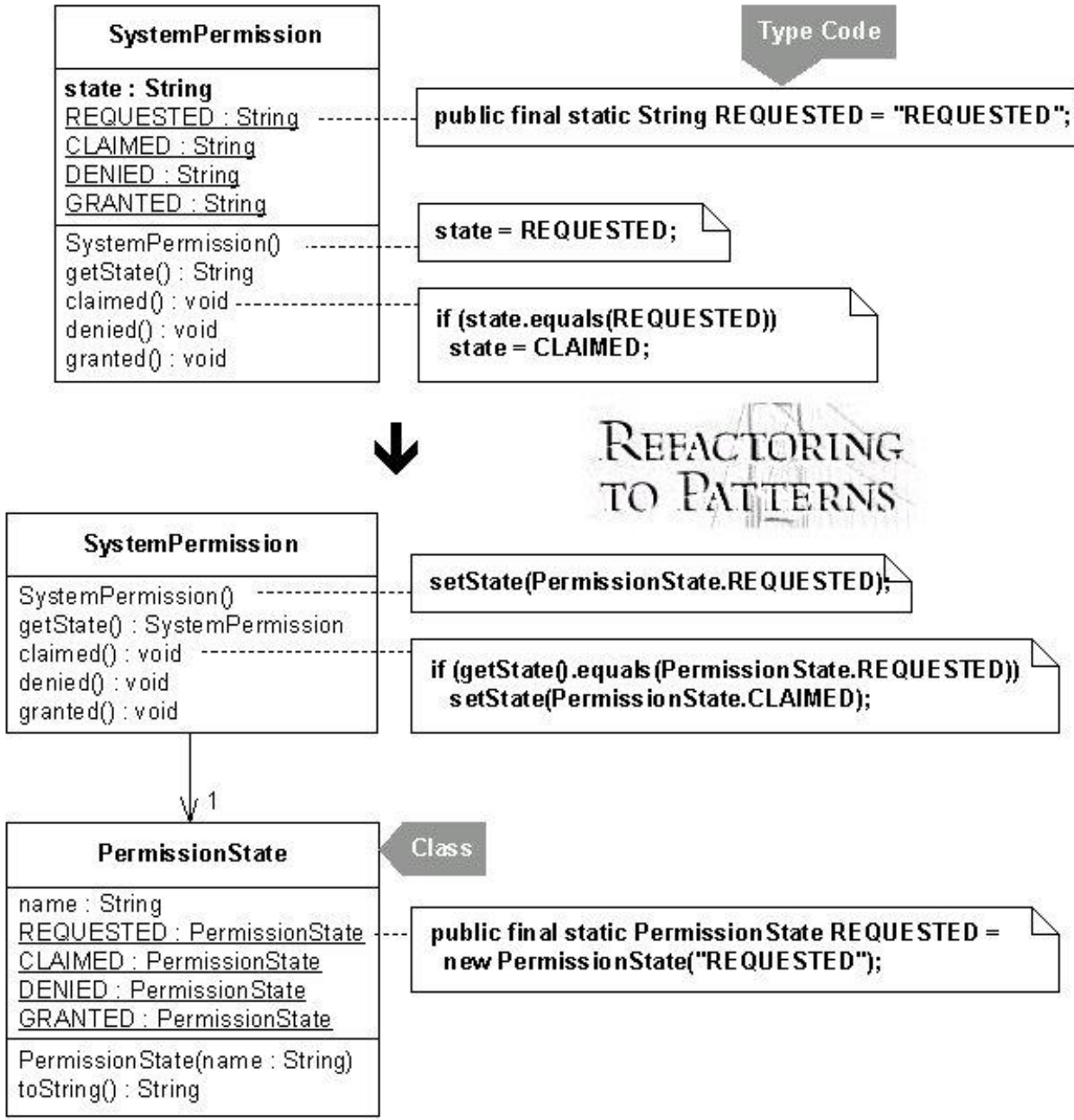
Switch statements

- Definition
  - A method is long and complex due to containing many “switch” or conditional statements.
- Refactoring
  - Replace type checking with subclasses.
  - Replace type checking with State/Strategy design pattern.
  - Replace conditional statements with polymorphism.

Replace Conditional Logic with Strategy



Replace Type Code with Class



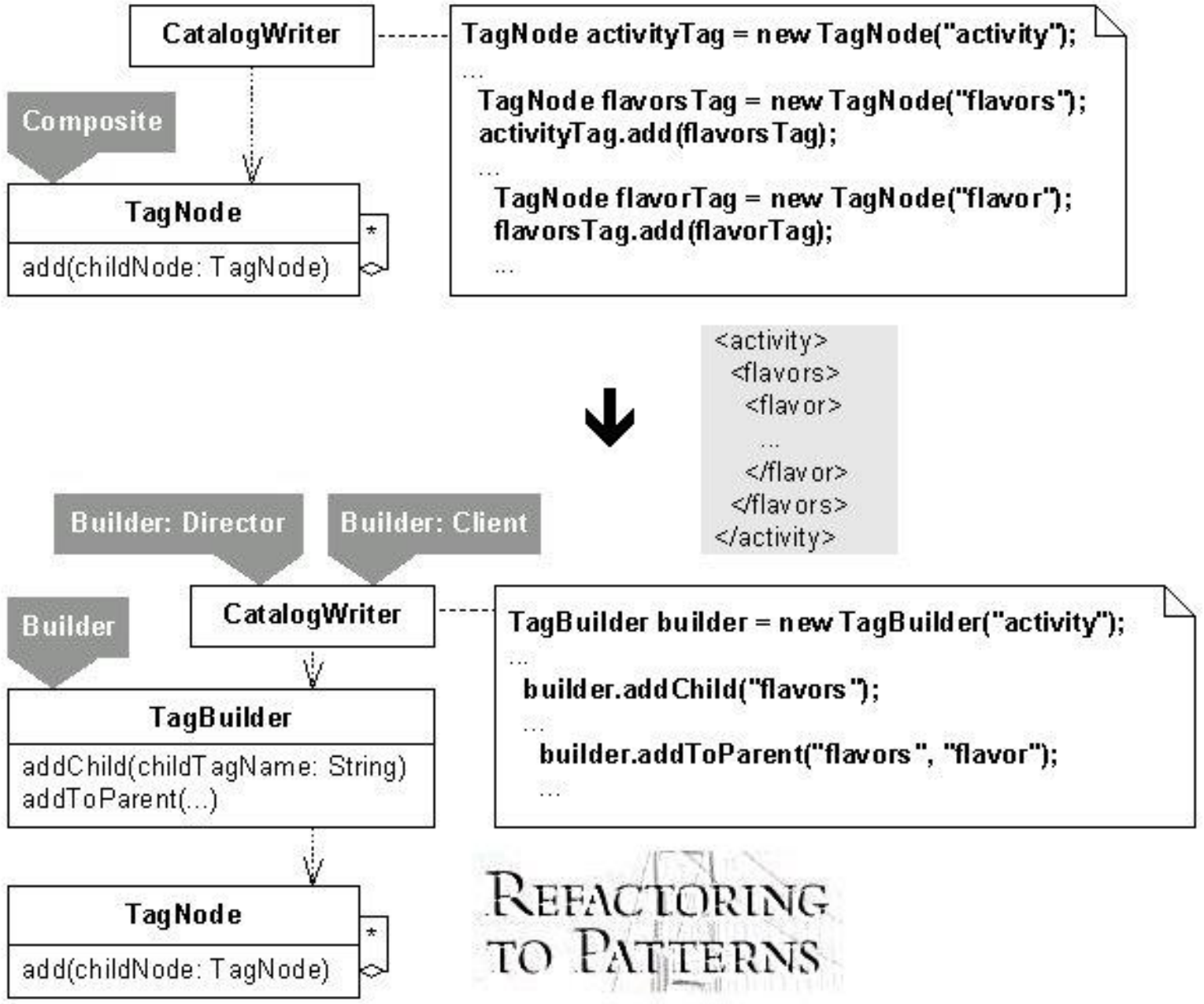
Message Chains

- Definition
  - There are long cascading method invocations.
- Refactoring
  - Extract and move method.

Inappropriate Intimacy

- Definition
  - A class has many associations with private members of another class.
- Refactoring
  - Move method/attribute
  - Extract class
  - Hide delegation
  - Encapsulate Composite with the Builder pattern.

Encapsulate Composite with Builder



Refused Bequest

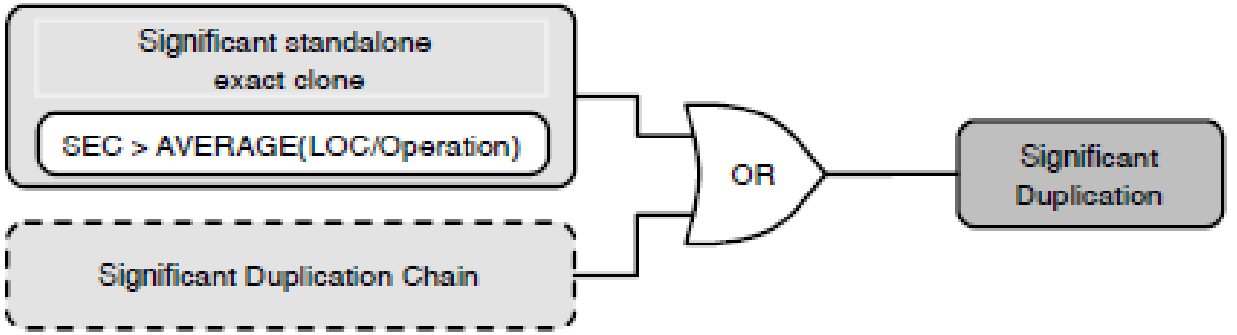
- Definition
  - A derived class does not need to inherit certain members of the base class.
- Refactoring
  - Push down method/attribute to the subclasses.

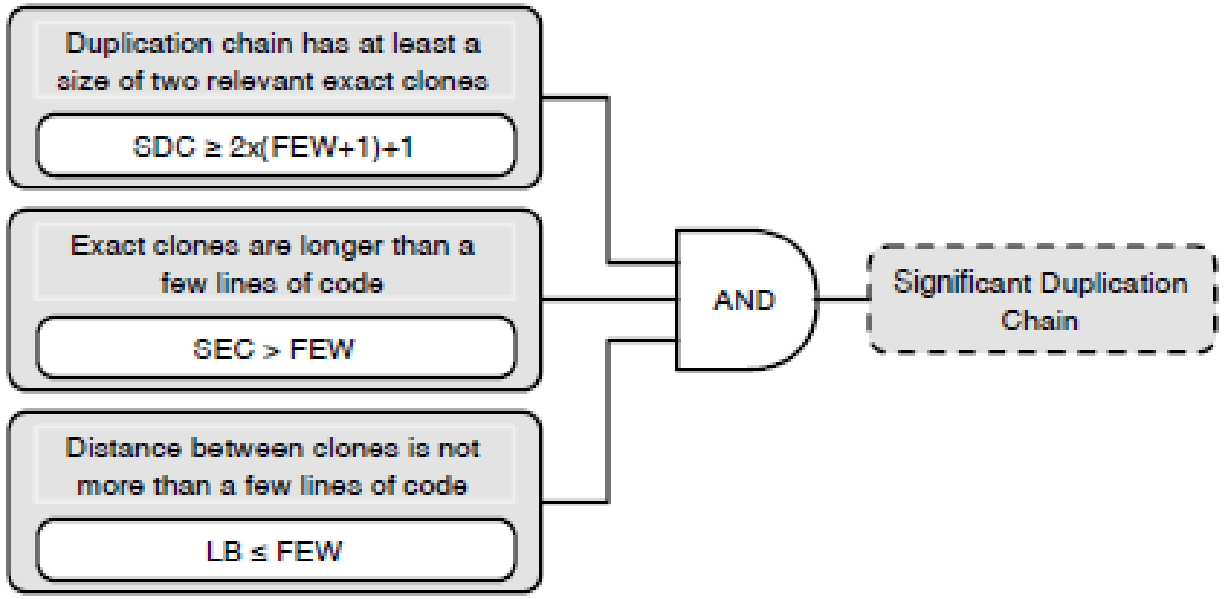
Detection of antipatterns

- It is possible to detect certain code antipatterns based on metrics.
- We can define thresholds on the metrics, combine the relevant conditions and detect the antipatterns.
- Definition of thresholds
  - Statistical: LOW = AVG - ST.DEV., HIGH = AVG + ST.DEV., VERY_HIGH = (AVG + ST.DEV.)*1.5
  - Semantic: a quarter, a third, half, two thirds, three quarters
  - General: 0 = NONE, 1 = ONE, 2-5 = FEW, 7 = Short Memory Cap, >7 = MANY

Duplicated Code

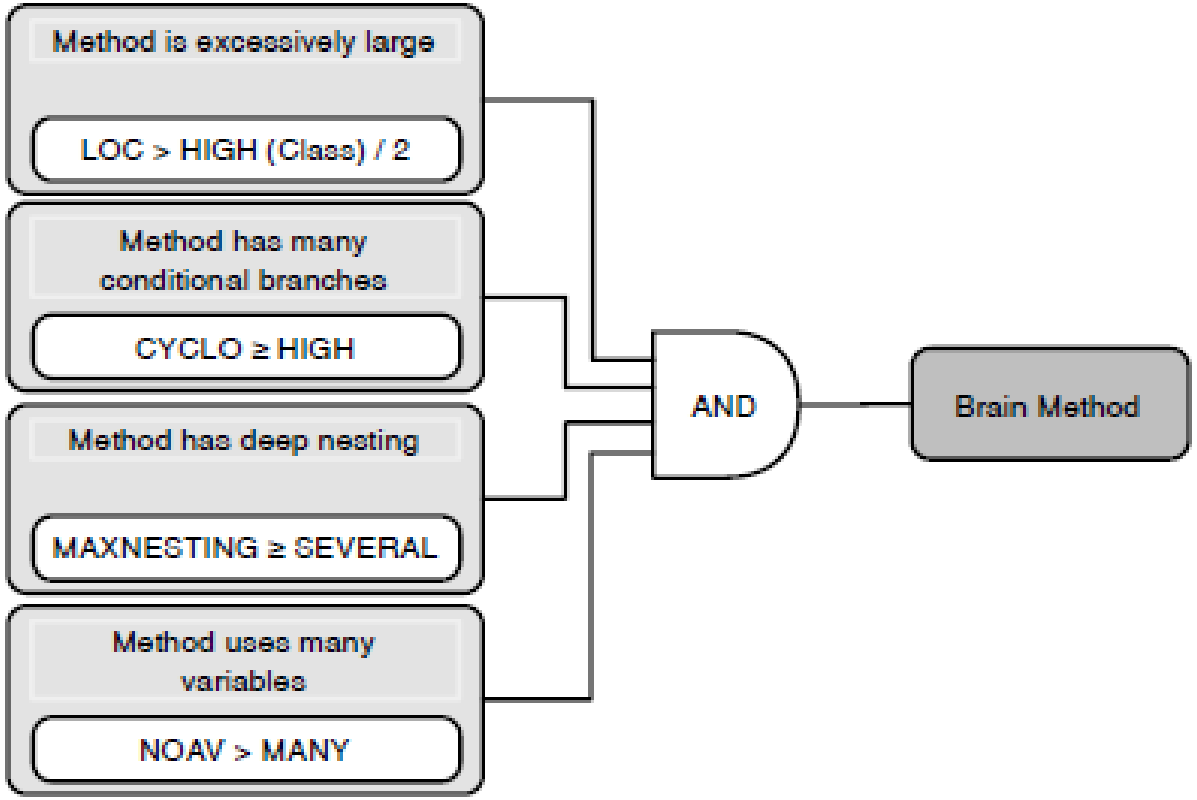
- SEC = Size of exact clone
  - Number of lines of exact clone.
- LB = Line Bias
  - Distance between two exact clones.
  - Number of equal lines between the two clones.
- SDC = Size of Duplication Chain
  - Number of exact clones in a duplication chain.
  - Duplication chain = exact clones that are close to each other in terms of LB.





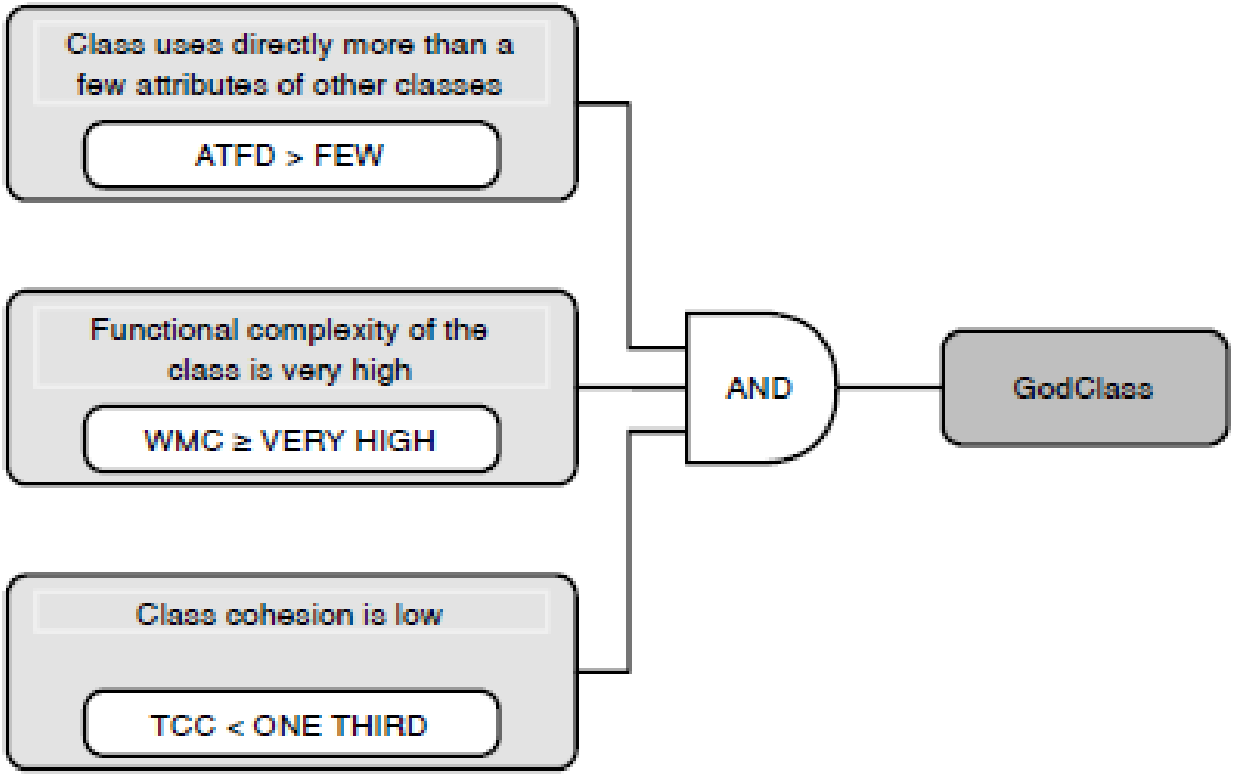
Long Method

- NOAV = Number of Accessed Variables
- MAXNESTING = Maximum Nesting Level



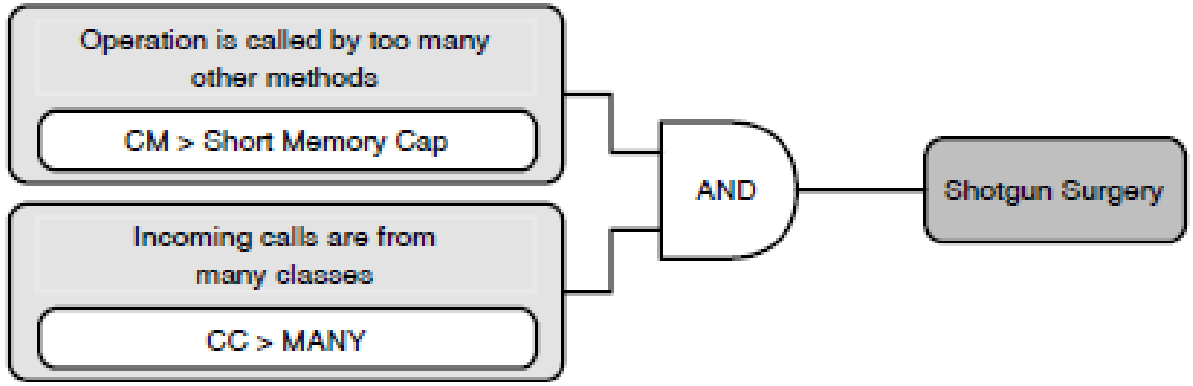
Large Class

- ATFD = Access to Foreign Data
  - Number of classes from which the class accesses attributes.



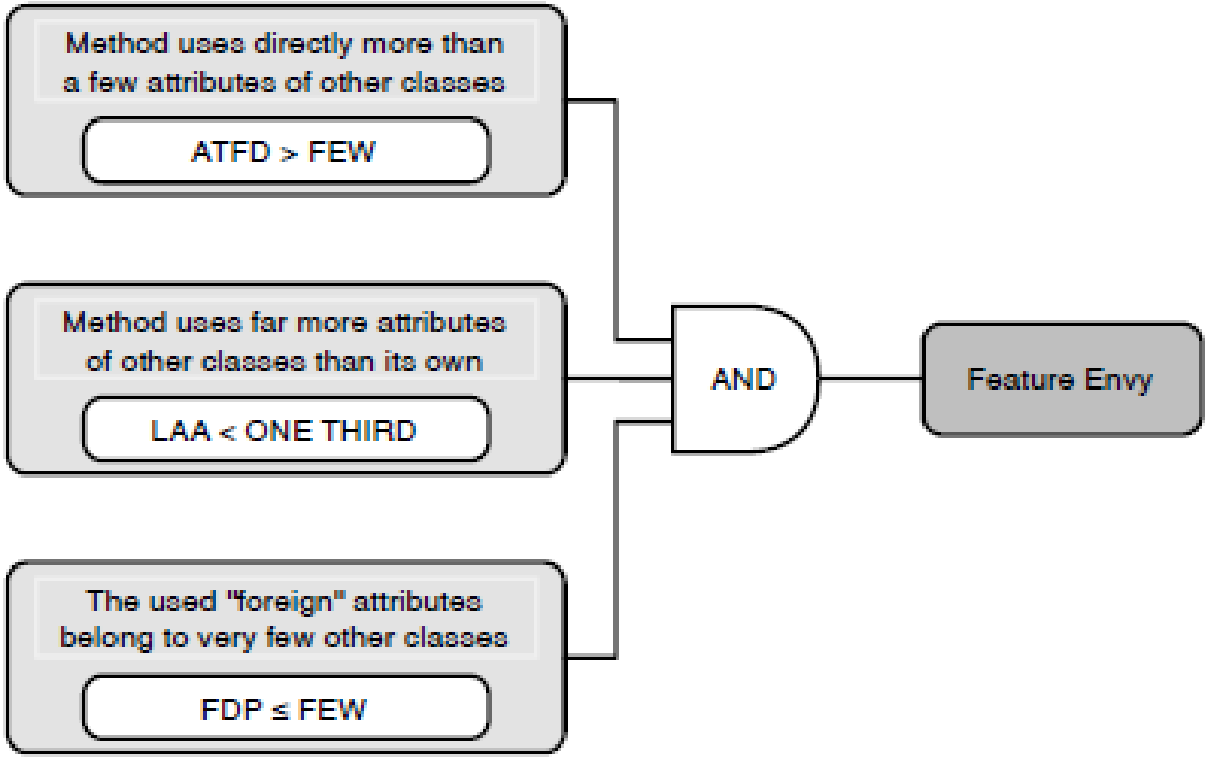
Shotgun Surgery

- CM = Changing Methods
  - Number of methods that call the measured method.
- CC = Changing Classes
  - Number of classes where the CM are defined.



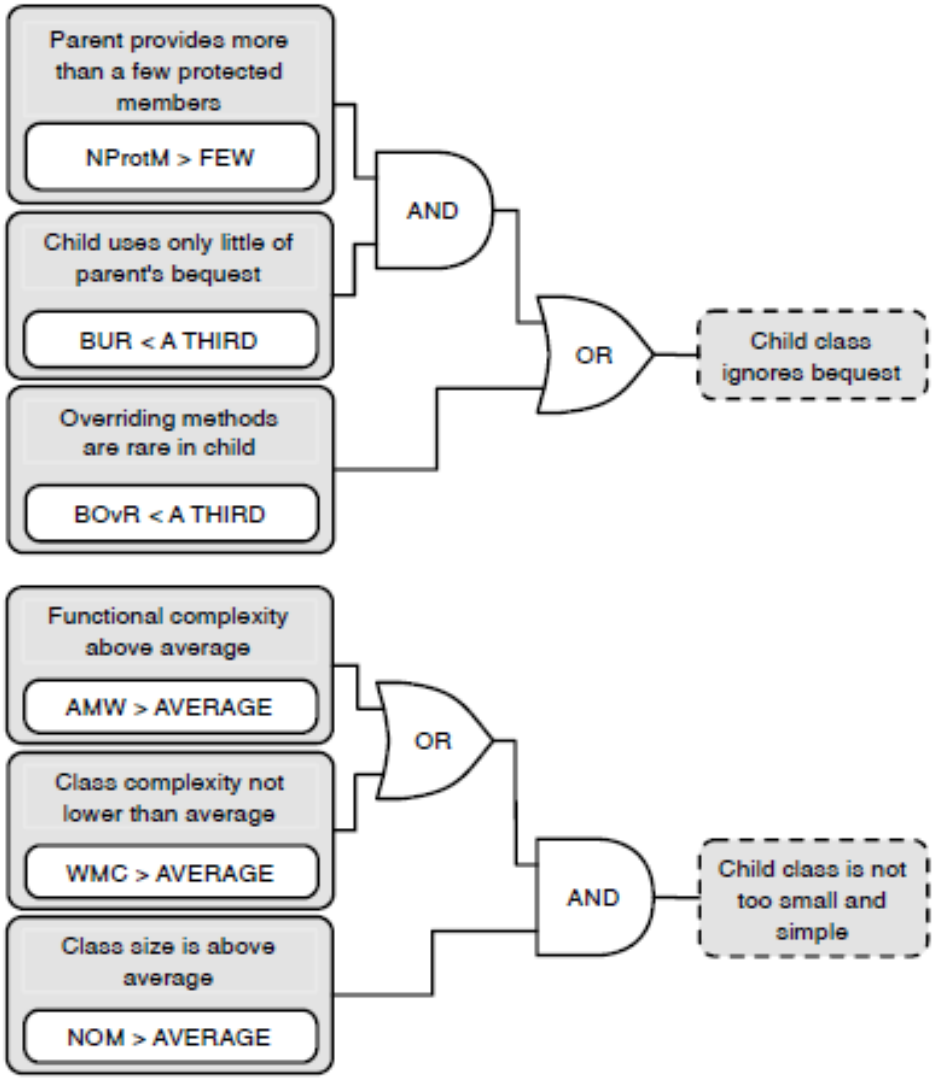
Feature Envy

- LAA = Locality of Attribute Accesses
  - Number of attributes belonging to the class of the method divided by the total number of attributes accessed by the method.
- FDP = Foreign Data Providers
  - Number of classes where the ATFD attributes are defined.

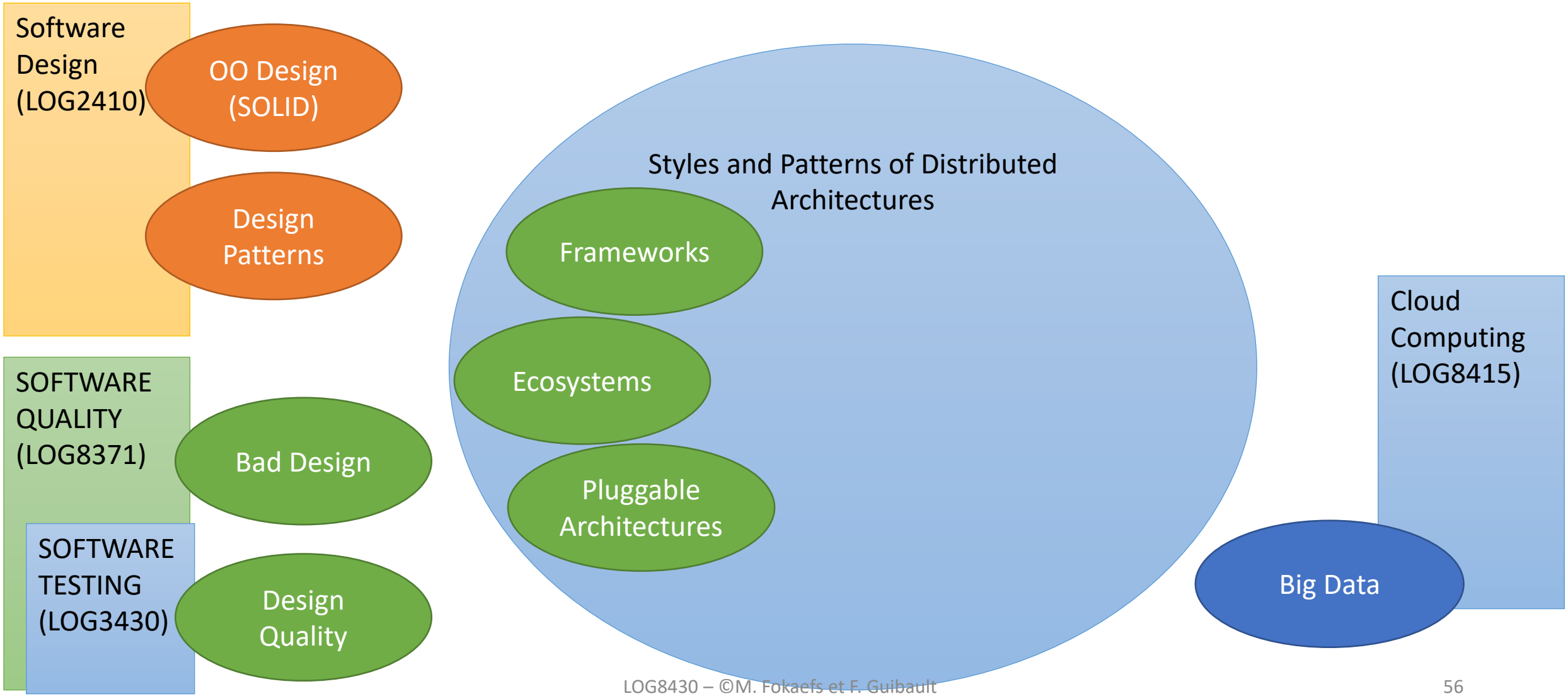


Refused Bequest

- NProtM = Number of Protected Members
- BUR = Base-class Usage Ratio
  - Usage ratio of protected members.
- BOvR = Base-class Overriding Ratio
  - Ratio of overridden members.
- AMW = Average Method Weight
  - Average complexity of all methods of a class.



Next time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