Course Notes Set 12:

Object-Oriented Metrics

Computer Science and Software Engineering
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Object-Oriented Metrics

- CK Metrics
  - Proposed by Chidamber and Kemerer
  - class-based metrics
- LK Metrics
  - Proposed by Lorenz and Kidd
  - class-based and operation-based
- MOOD Metrics
  - Proposed by Harrison, Counsell, and Nithi
  - class-based

CK Metrics

- Weighted methods per class (WMC)
  - The sum of the complexity values for all the methods of a given class.
  - They do not specify the specific complexity metric to use (e.g., cyclomatic complexity).
  - Indicator of implementation and testing effort for a class. The higher the value, the more effort required.
  - A possible indication of reusability.
  - WMC should be kept low.

CK Metrics

- Depth of inheritance tree (DIT)
  - The length of the longest path from the root of the inheritance hierarchy to a leaf class.
  - As DIT increases, the lower classes in the hierarchy inherit a greater number of data and methods, thus making their behavior more difficult to understand and causing testing to require more effort.
  - A large DIT value implies greater design complexity, but also greater reuse.

CK Metrics

- Number of children (NOC)
  - A count of the number of classes immediately subordinate to a given class in the hierarchy.
  - As the NOC value grows, reuse increases but the amount of testing also increases.
  - Also, a large NOC value may indicate an inappropriate abstraction.

CK Metrics

- Coupling between classes (CBO)
  - The amount of collaboration and interaction between a given class and the other classes in the system.
  - As the CBO value increases, reusability decreases.
  - Also, a high CBO indicates potential difficulty in modifying the class and the subsequent testing of the modifications.
  - CBO should be kept low.

CK Metrics

- Response for a class (RFC)
  - The number of methods that can potentially be executed in response to a message received by an object of a given class.
  - As the RFC value increases, testing effort and design complexity also increase.
  - RFC should be kept low.

CK Metrics

- Lack of cohesion in methods (LCOM)
  - The number of methods in a given class that access one or more of the same instance variables.
  - The higher the LCOM value, the lower the cohesion of methods, and greater the coupling.
  - A high LCOM value could indicate the need to break the class apart into multiple classes.

LK Metrics

- Class size (CS)
  - The total number of methods (both inherited and local) plus the total number of attributes (both inherited and local) encapsulated by a given class.
  - Inherited members should be weighted more heavily than local members.
  - Large values of CS could indicate that the class is too large; that is, that it encasulates too much behavior, structure, and responsibility.
  - High CS values may also indicate lower reusability.

LK Metrics

- Number of operations overridden by a subclass (NOO)
  - A count of the methods in subclasses that have been redefined.
  - Large NOO values could indicate a design problem, since the model of the class seems to be violated.

LK Metrics

- Number of operations added by a subclass (NOA)
  - A count of the new methods appearing in subclasses.
  - A large NOA value could indicate a design abstraction violation.
  - As CK DIT increases, NOA should decrease.

LK Metrics

- Specialization index (SI)
  - The degree to which subclasses are differentiated from superclasses.
  - SI is computed as NOO multiplied by the level at which the class resides in the inheritance hierarchy divided by the total number of methods defined by the class.
  - A high SI could indicate a lack of conformance to superclass abstractions.

LK Metrics

- Average operation size (OS_{avg})
  - Number of messages sent by a given method.
  - A high OS_{avg} value can indicate a poor allocation of responsibility within the class.

LK Metrics

- Operation complexity (OC)
  - An indication of method complexity, such as cyclomatic complexity
  - OC should be kept as low as possible.

LK Metrics

- Average number of parameters per operation (NP_{avg})
  - An average method parameter list size
  - Should be kept low

MOOD Metrics

- Method inheritance factor (MIF)
  - The degree to which inheritance is used in the class hierarchy.

MOOD Metrics

- Coupling factor (CF)
  - A measure of how dependent and interactive classes are

MOOD Metrics

- Polymorphism factor (PF)
  - A measure of the relative amount of dynamic binding in a system.
  - The number of methods that redefine inherited methods divided by the maximum number of possible distinct polymorphic situations.

OO Testing Metrics (Binder)

- LCOM
- Percent public and protected (PAP)
- Public access to data members (PAD)
- Number of root classes (NOR)
- Fan-in (FIN)
- NOC, DIT
- Class complexity metrics
- Polymorphism metrics

McCabe OO Metrics

- Percent Public Data (PCTPUB)
  - Percentage of public and protected data within a class.
- Access to Public Data (PUBDATA)
  - The number of accesses to public and protected data.

McCabe OO Metrics

- Percent of Unoverloaded Calls (PCTCALL)
  - Number of unoverloaded calls in the system.
- Number of Roots (ROOTCNT)
  - Total number of class hierarchy roots in the system.
- Fan-in (FANIN)
  - Number of classes from which a given class is derived.

McCabe OO Metrics

- Maximum v(G) (MAXV)
  - Maximum cyclomatic complexity for any single method within a given class.
- Maximum ev(G) (MAXEV)
  - Maximum essential complexity for any single method within a given class.
- Hierarchy Quality (QUAL)
  - Number of classes in a system that are dependent upon their descendents.

CK Metrics as Quality Indicators

- Empirical study by Basili and others.
- Collected CK metrics data on 8 medium-sized information management systems based on identical requirements.
- All 8 systems were developed with the same process model (modified waterfall) along with a well-known OOA/D method, and implemented in C++.

CK Metrics as Quality Indicators

- Analysis of the data shows that 5 of 6 CK metrics are useful to predict class fault-proneness during the early phases of the life cycle.
- Larger values of WMC, DIT, RFC, and CBO correlate with a greater probability of detecting a defect in a given class.
- Larger values of NOC correlate with a lower probability of detecting a defect in a given class.
- LCOM was not significant.