Refactoring - General Idea and Process

Idaho State University | Computer Science

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Outcomes

After today's lecture you will be able to:

- Understand and describe the general idea of refactoring
- Understand and describe the process of refactoring
- Understand and be able to evaluate the impacts of refactoring on quality

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Refactoring

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General Idea

- Developers continuously modify, enhance and adapt software.
- As software evolves and strays away from its original design, three things happen.
  - Decreased understandability
  - Decreased reliability
  - Increased maintenance cost
- Decreased understandability is due to
  - Increased complexity of code
  - Out-of-date documentation
  - Code not conforming to standards

General Idea

- Decrease the complexity of software by improving its internal quality by restructuring the software.
- Restructuring applied on object-oriented software is called refactoring.
- Restructuring means reorganizing software (source code + documentation) to give it a different look, or structure.

General Idea

- Source code is restructured to improve some of its non-functional requirements:
  - Readability
  - Extensibility
  - Maintainability
  - Modularity
- Restructuring does not modify the software's functionalities.
- Restructuring can be performed while adding new features.

General Idea

- Software restructuring is informally stated as the modifications of software to make it
  - easier to understand;
  - easier to change;
  - easier to change its documentation;
  - less susceptible to faults when changes are made to it.

General Idea

- A higher level goal of restructuring is to increase the software value
  - external software value: fewer faults in software is seen to be better by customers
  - internal software value: a well-structured system is less expensive to maintain
- Simple examples of restructuring
  - Pretty printing
  - Meaningful names for variables
  - One statement per line of source code

General Idea

- Developers and managers need to be aware of restructuring for the following reasons
  - better understandability
  - keep pace with new structures
  - better reliability
  - longer lifetime
  - automated analysis

General Idea

- Characteristics of restructuring and refactoring
  - The objective of restructuring and refactoring is to improve the internal and external values of software.
  - Restructuring preserves the external behavior of the original program.
  - Restructuring can be performed without adding new requirements.
  - Restructuring generally produces a program in the same language.
    - Example: a C program is restructured into another C program.

Refactoring Process

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Refactoring Process Activities

- To restructure a software system, one follows a process with well defined activities.
  - Identify what to refactor.
  - Determine which refactorings to apply.
  - Ensure that refactoring preserves the software's behavior.
  - Apply the refactorings to the chosen entities.
  - Evaluate the impacts of the refactorings.
  - Maintain consistency.

Identify what to refactor

- The programmer identifies what to refactor from a set of high-level software artifacts.
  - source code;
  - design documents; and
  - requirements documents.
- Next, focus on specific portions of the chosen artifact for refactoring.
  - Specific modules, functions, classes, methods, and data can be identified for refactoring.

Identify what to refactor

- The concept of code smell is applied to source code to detect what should be refactored.
- A code smell is any symptom in source code that possibly indicates a deeper problem.
- Examples of code smell are:
  - duplicate code;
  - long parameter list;
  - long methods;
  - large classes;
  - message chain.

Identify what to refactor

- Entities to be refactored at the design level
  - software architecture;
    - class diagram;
    - statechart diagram; and
    - activity diagrams;
  - global control flow; and
  - database schemas.

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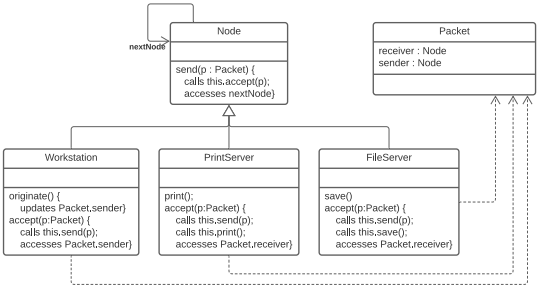
Determine refactorings to apply



- R1: Rename method `print` to `process` in class `PrintServer`.
- R2: Rename method `save` to `process` in class `FileServer`. (R1 and R2 are to be done together.)
- R3: Create a superclass `Server` from `PrintServer` and `FileServer`.
- R4: Pull up method `accept` from `PrintServer` and `FileServer` to the superclass `Server`.
- R5: Move method `accept` from `PrintServer` to class `Packet`, so that data packets themselves will decide what actions to take.

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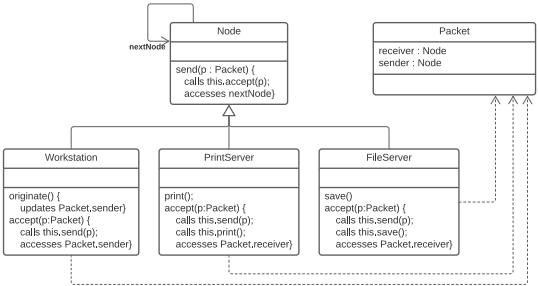
Determine refactorings to apply



- R6: Move method `accept` from `FileServer` to `Packet`.
- R7: Encapsulate field `receiver` in `Packet` so that another class cannot directly access this field.
- R8: Add parameter `p` of type `Packet` to method `print` in `PrintServer` to print the contents of a packet.
- R9: Add parameter `p` of type `Packet` to method `save` in class `FileServer` so that the contents of a packet can be saved.

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Determine refactorings to apply

- **R1 – R9** indicate that a large number of refactorings can be identified even for a small system.
- A subset of the entire set of refactorings need to be carefully chosen because of the following reasons.
  - Some refactorings must be applied together.
    - Example: R1 and R2 are to be applied together.
  - Some refactorings must be applied in certain orders.
    - Example: R1 and R2 must precede R3.
  - Some refactorings can be individually applied, but they must follow an order if applied together.
    - Example: R1 and R8 can be applied in isolation. However, if both of them are to be applied, then R1 must occur before R8.
  - Some refactorings are mutually exclusive.
    - Example: R4 and R6 are mutually exclusive.

Determine refactorings to apply

- Tool support is needed to identify a feasible subset of refactorings.
- The following two techniques can be used to analyze a set of refactorings to select a feasible subset.
  - **Critical pair analysis**
    - Given a set of refactorings, analyze each pair for conflicts. A pair is said to be conflicting if both of them cannot be applied together.
    - Example: R4 and R6 constitute a conflicting pair.
  - **Sequential dependency analysis**
    - In order to apply a refactoring, one or more refactorings must be applied before.
    - If one refactoring has already been applied, a mutually exclusive refactoring cannot be applied anymore.
    - Example: after applying R1, R2, and R3, R4 becomes applicable. Now, if R4 is applied, then R6 is not applicable anymore.

Ensure preservation of behavior

- Ideally, the input/output behavior of a program after refactoring is the same as the behavior before refactoring.
- In many applications, preservation of non-functional requirements is necessary.
- A non-exclusive list of such non-functional requirements is as follows:
- **Temporal constraints:** A temporal constraint over a sequence of operations is that the operations occur in a certain order.
  - For real-time systems, refactorings should preserve temporal constraints.
- **Resource constraints:** The software after refactoring does not demand more resources: memory, energy, communication bandwidth, and so on.
- **Safety constraints:** It is important that the software does not lose its safety properties after refactoring.

Ensure preservation of behavior

- Two pragmatic ways of showing that refactoring preserves the software's behavior.
  - Testing
    - Exhaustively test the software before and after applying refactorings, and compare the observed behavior on a test-by-test basis.
  - Verification of preservation of call sequence
    - Ensure that the sequence(s) of method calls are preserved in the refactored program.

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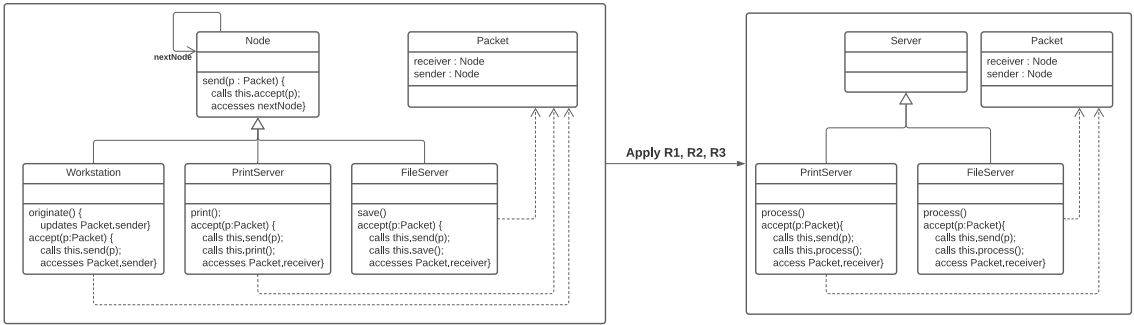
Apply the refactorings

- The following transformation is obtained by:
  - focusing on the classes `FileServer`, `PrintServer`, and `Packet`
  - applying refactorings R1, R2, and R3.



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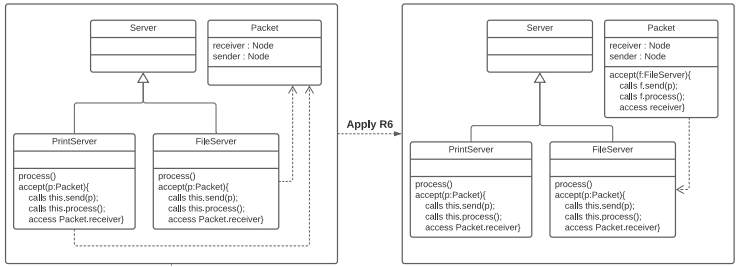
Apply the refactorings



- R4: Pull up method `accept` from `PrintServer` and `FileServer` to the superclass `Server`.
- R6: Move method `accept` from `FileServer` to `Packet`.

Evaluate impacts on quality

- Refactorings impact both **internal** and **external** qualities of software.

- **Internal** qualities of software include
  - size
  - complexity
  - coupling
  - cohesion
  - testability

- **External** qualities of software include:
  - performance
  - reusability
  - maintainability
  - extensibility
  - robustness
  - scalability

Evaluate impacts on Quality

- In general, refactoring techniques are **highly specialized**, with one technique improving a **small number** of quality attributes.

- For example,
  - some refactorings eliminate code duplication;
  - some raise reusability;
  - some improve performance; and
  - some improve maintainability.

Evaluate impacts on Quality

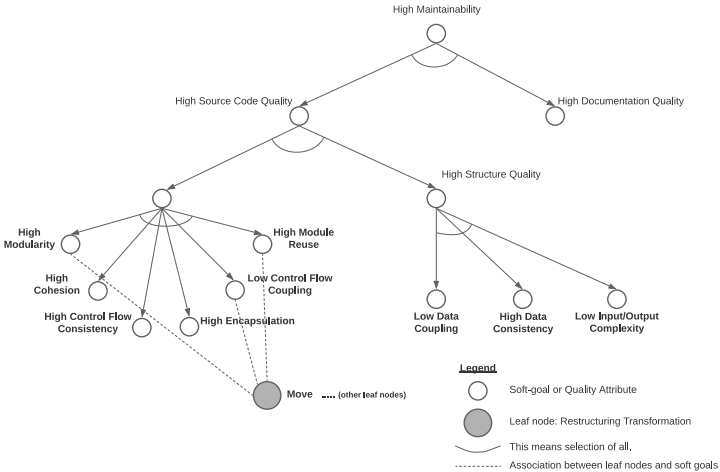
- By measuring the impacts of refactorings on internal qualities, their impacts on external qualities can be measured.
- Example of measuring external qualities
  - Some examples of software metrics are coupling, cohesion, and size.
  - Decreased coupling, increased cohesion, and decreased size are likely to make a software system more maintainable.
  - To assess the impact of a refactoring technique for better maintainability, one can evaluate the metrics before refactoring and after refactoring, and compare them.

Maintain Consistency

- Rather than evaluate the impacts after applying refactorings, one selects refactorings such that the program after refactoring possesses better quality attributes.
- The concept of a **soft-goal graph** help select refactorings.

Example

- A soft-goal graph for quality attribute (maintainability) rooted at high maintainability (desired change).



- The internal nodes represent successive refinements of the attribute and are basically the soft goals.
- The leaf nodes represent refactoring transformations which contribute positively/negatively to soft-goals which appear above them in the hierarchy.

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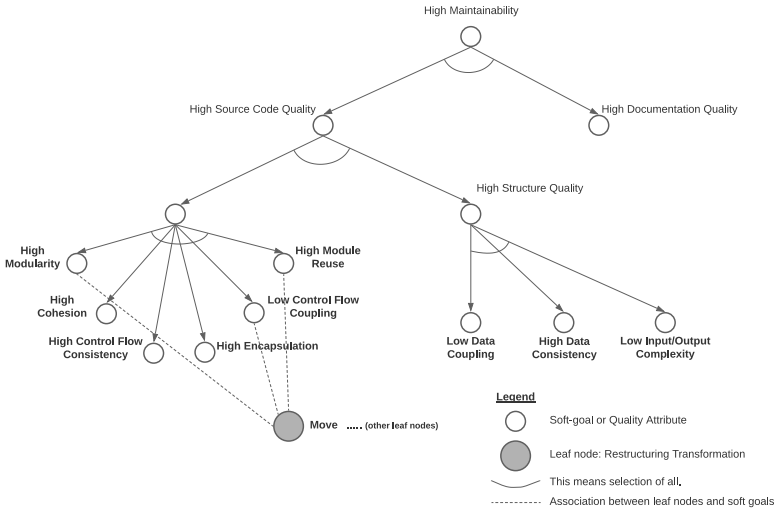
Example

- A partial example of a soft goal graph with one leaf node, **Move**



- The dotted lines between **Move** and three soft goals
  - High Modularity
  - High Module Reuse
  - Low Control Flow Coupling
- Implies that the Move transformation impacts those three soft goals

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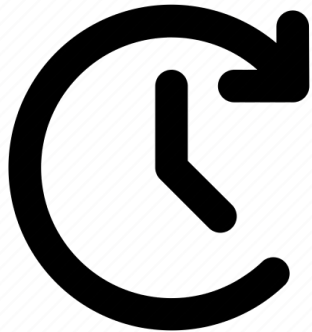
For Next Time

- Review EVO Chapter 7.1 - 7.2
- Read EVO Chapter 7.3 - 7.4
- Watch Lecture 18



Are there any questions?