Principles of Software Construction: Objects, Design, and Concurrency

Software engineering in practice

Toward people and process

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Administrivia

- Homework 5c due last night!
- Homework 6 coming soon
  - Checkpoint deadline
- Happy Thanksgiving break!

Key concepts from last Thursday

Lambda syntax

Syntax	**Example**
parameter -> expression	x -> x * x
parameter -> block	s -> { System.out.println(s); }
(parameters) -> expression	(x, y) -> Math.sqrt(x*x + y*y)
(parameters) -> block	(s1, s2) -> { System.out.println(s1 + "," + s2); }
(parameter decls) -> expression	(double x, double y) -> Math.sqrt(x*x + y*y)
(parameters decls) -> block	(List<?> list) -> { Arrays.shuffle(list); Arrays.sort(list); }

Method references – a more succinct alternative to lambdas

- Lambdas are succinct

```
map.merge(key, 1, (count, incr) -> count + incr);
```

- But *method references* can be more so

```
map.merge(key, 1, Integer::sum);
```

- The more parameters, the bigger the win
  - But parameter names *may* provide documentation
  - If you use a lambda, choose parameter names carefully!

Simple stream examples – mapping, filtering, sorting, etc.

```
List<String> longStrings = stringList.stream()
    .filter(s -> s.length() > 3)
    .collect(Collectors.toList());

List<String> firstLetters = stringList.stream()
    .map(s -> s.substring(0,1))
    .collect(Collectors.toList());

List<String> firstLettersOfLongStrings = stringList.stream()
    .filter(s -> s.length() > 3)
    .map(s -> s.substring(0,1))
    .collect(Collectors.toList());

List<String> sortedFirstLettersWithoutDups = stringList.stream()
    .map(s -> s.substring(0,1))
    .distinct()
    .sorted()
    .collect(Collectors.toList());
```

What Josh didn't show you…

Stream interface is a monster (1/3)

```
public interface Stream<T> extends BaseStream<T, Stream<T>> {
 // Intermediate Operations
 Stream<T> filter(Predicate<T>);
 <R> Stream<R> map(Function<T, R>);
 IntStream mapToInt(ToIntFunction<T>);
 LongStream mapToLong(ToLongFunction<T>);
 DoubleStream mapToDouble(ToDoubleFunction<T>);
 <R> Stream<R> flatMap(Function<T, Stream<R>>);
 IntStream flatMapToInt(Function<T, IntStream>);
 LongStream flatMapToLong(Function<T, LongStream>);
 DoubleStream flatMapToDouble(Function<T, DoubleStream>);
 Stream<T> distinct();
 Stream<T> sorted();
 Stream<T> sorted(Comparator<T>);
 Stream<T> peek(Consumer<T>);
 Stream<T> limit(long);
 Stream<T> skip(long);
```

Stream interface is a monster (2/3)

```
// Terminal Operations
void forEach(Consumer<T>);          // Ordered only for sequential streams
void forEachOrdered(Consumer<T>);   // Ordered if encounter order exists
Object[] toArray();
<A> A[] toArray(IntFunction<A[]> arrayAllocator);
T reduce(T, BinaryOperator<T>);
Optional<T> reduce(BinaryOperator<T>);
<U> U reduce(U, BiFunction<U, T, U>, BinaryOperator<U>);
<R, A> R collect(Collector<T, A, R>); // Mutable Reduction Operation
<R> R collect(Supplier<R>, BiConsumer<R, T>, BiConsumer<R, R>);
Optional<T> min(Comparator<T>);
Optional<T> max(Comparator<T>);
long count();
boolean anyMatch(Predicate<T>);
boolean allMatch(Predicate<T>);
boolean noneMatch(Predicate<T>);
Optional<T> findFirst();
Optional<T> findAny();
```

Stream interface is a monster (3/3)

```
    // Static methods: stream sources
    public static <T> Stream.Builder<T> builder();
    public static <T> Stream<T> empty();
    public static <T> Stream<T> of(T);
    public static <T> Stream<T> of(T...);
    public static <T> Stream<T> iterate(T, UnaryOperator<T>);
    public static <T> Stream<T> generate(Supplier<T>);
    public static <T> Stream<T> concat(Stream<T>, Stream<T>);
}
```

In case your eyes aren't glazed yet

```
public interface BaseStream<T, S extends BaseStream<T, S>>
   extends AutoCloseable {
 Iterator<T> iterator();
 Spliterator<T> spliterator();
 boolean isParallel();
 S sequential();  // May have little or no effect
 S parallel();    // May have little or no effect
 S unordered();   // Note asymmetry wrt sequential/parallel
 S onClose(Runnable);
 void close();
}
```

It keeps going: `java.util.stream.Collectors`

```
... toList()
... toMap(...)
... toSet(...)
... reducingBy(...)
... groupingBy(...)
... partitioningBy(...)

        .
        .
        .
```

It keeps going: `java.util.stream.Collectors`

```
... toList()
... toMap(...)
... toSet(...)
... reducingBy(...)
... groupingBy(...)
... partitioningBy(...)

        .
        .
        .
static <T,K,D,A,M extends Map<K,D>> Collector<T,?,M> groupingBy(
    Function<? super T,? extends K> classifier,
    Supplier<M> mapFactory,
    Collector<? super T,A,D> downstream)
```

Optional<T> – a third way to indicate the absence of a result

```
public final class Optional<T> {
    boolean isPresent();
    T get();

    void ifPresent(Consumer<T>);
    Optional<T> filter(Predicate<T>);
    <U> Optional<U> map(Function<T, U>);
    <U> Optional<U> flatMap(Function<T, Optional<U>>);
    T orElse(T);
    T orElseGet(Supplier<T>);
    <X extends Throwable> T orElseThrow(Supplier<X>) throws X;
}
```

Changes to existing libraries… e.g.,

```
public interface Collection<E> {
  …
  default Stream<E> stream();
  default Stream<E> parallelStream();
  default Spliterator<E> spliterator();
}
```

Overall: Streams design discussion

- Recall the fundamental API design principles…

Today: Software engineering in practice

- An introduction to software engineering
- Methodologies discussion: Test-driven development

What is software engineering?

1968 NATO Conference on Software Engineering

institute for SOFTWARE RESEARCH

Compare to other forms of engineering

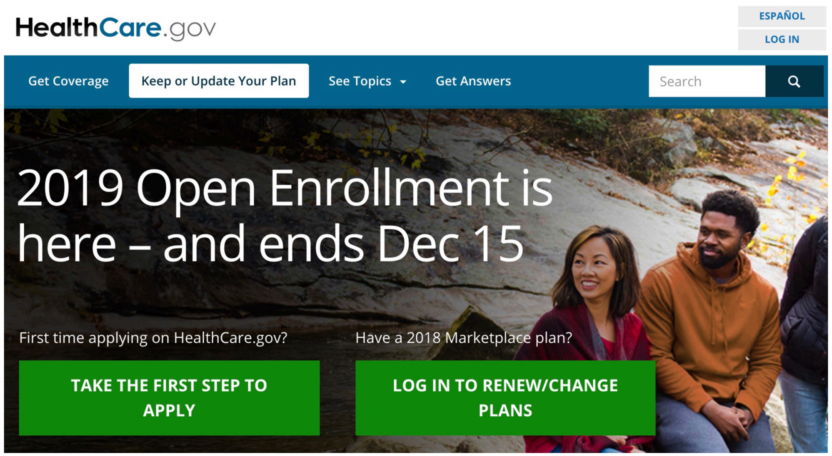
- e.g., Producing a car or bridge
  - Estimable costs and risks
  - Well-defined expected results
  - High quality
- Separation between plan and production
- Simulation before construction
- Quality assurance through measurement
- Potential for automation

Software engineering is ‘‘the establishment and use of sound ***engineering principles*** *in order to obtain,* ***economically,*** *software that is* ***reliable*** *and works* ***efficiently*** *on* ***real*** *machines.”*

[Bauer 1975, S. 524]

Software engineering in the real world

- e.g., HealthCare.gov
  - Estimable costs and risks
  - Well-defined expected results
  - High quality
- Separation between plan and production
- Simulation before construction
- Quality assurance through measurement
- Potential for automation



Major topics in 17-313 (Foundations of SE)

- Process considerations for software development
- Requirements elicitation, documentation, and evaluation
- Design for quality attributes
- Strategies for quality assurance
- Empirical methods in software engineering
- Time and team management
- Economics of software development

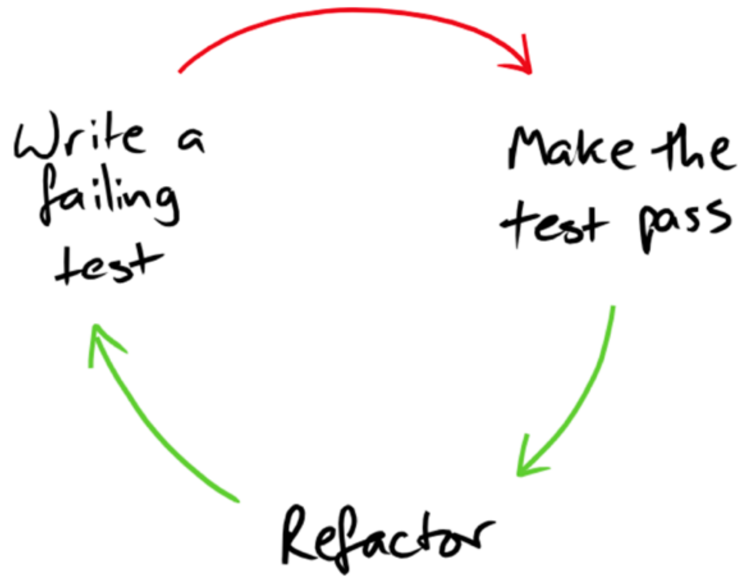
The foundations of our Software Engineering program

- Core computer science fundamentals
- Building good software, organizing software projects
  - Development teams, customers, and users
  - Process, requirements, estimation, management, and methods
- The larger context of software
  - Business, society, policy
- Engineering experience
- Communication skills
  - Written and oral

Today: Software engineering in practice

- An introduction to software engineering
- Methodologies discussion: Test-driven development

Test-driven development (TDD), informally



From Growing Object-Oriented Software by Nat Pryce and Steve Freeman
http://www.growing-object-oriented-software.com/figures.html
@sebrose
http://cucumber.io

Test-driven development rules

1. You may only write production code to make a failing test pass
2. You may only write a minimally failing unit test
3. You may only write minimal code to pass the failing test

Test-driven development as a design process

"The act of writing a unit test is more an act of design and documentation than of verification. It closes a remarkable number of feedback loops, the least of which pertains to verification."

Advantages of test-driven development

- Clear place to start
- Iterative, agile design process
- Less wasted effort?
- Robust test suite, including regression tests

A test-driven development demo: Diamond Kata

- Given a letter, generate a diamond starting at ‘A’, with the given letter at the widest point.
  - e.g., `diamond('C')` would generate:

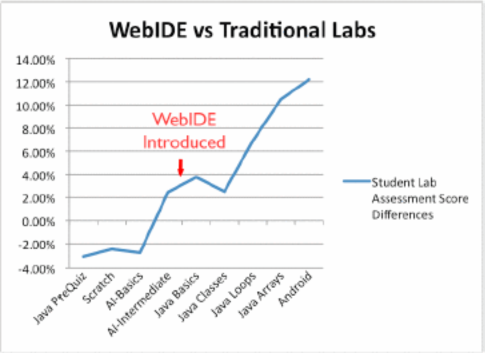
```
  A
 B B
C   C
 B B
  A
```

Test-driven development: Your impressions?

Empirical methods in software engineering

- How do we study the effectiveness of test-driven development compared to other methodologies?

Research on test-driven development (1/2)



- Hilton et al.: Students learn better when forced to write tests first
- Bhat et al.: At Microsoft, projects using TDD had greater than two times code quality, but 15% more upfront setup time
- George et al.: TDD passed 18% more test cases, but took 16% more time
- Scanniello et al.: Perceptions of TDD include: novices believe TDD improves productivity at the expense of internal quality

Research on test-driven development (2/2)

- Fucci et al.: Results: The Kruskal-Wallis tests did not show any significant difference between TDD and TLD in terms of testing effort (p-value = .27), external code quality (p-value = .82), and developers' productivity (p-value = .83).

- Fucci et al.: Conclusion: The claimed benefits of TDD may not be due to its distinctive test-first dynamic, but rather due to the fact that TDD-like processes encourage fine-grained, steady steps that improve focus and flow.

Summary

- Software engineering requires consideration of many issues, social and technical, above code-level considerations
- Interested? Take 17-313