Computer System Design & Application

计算机系统设计与应用A

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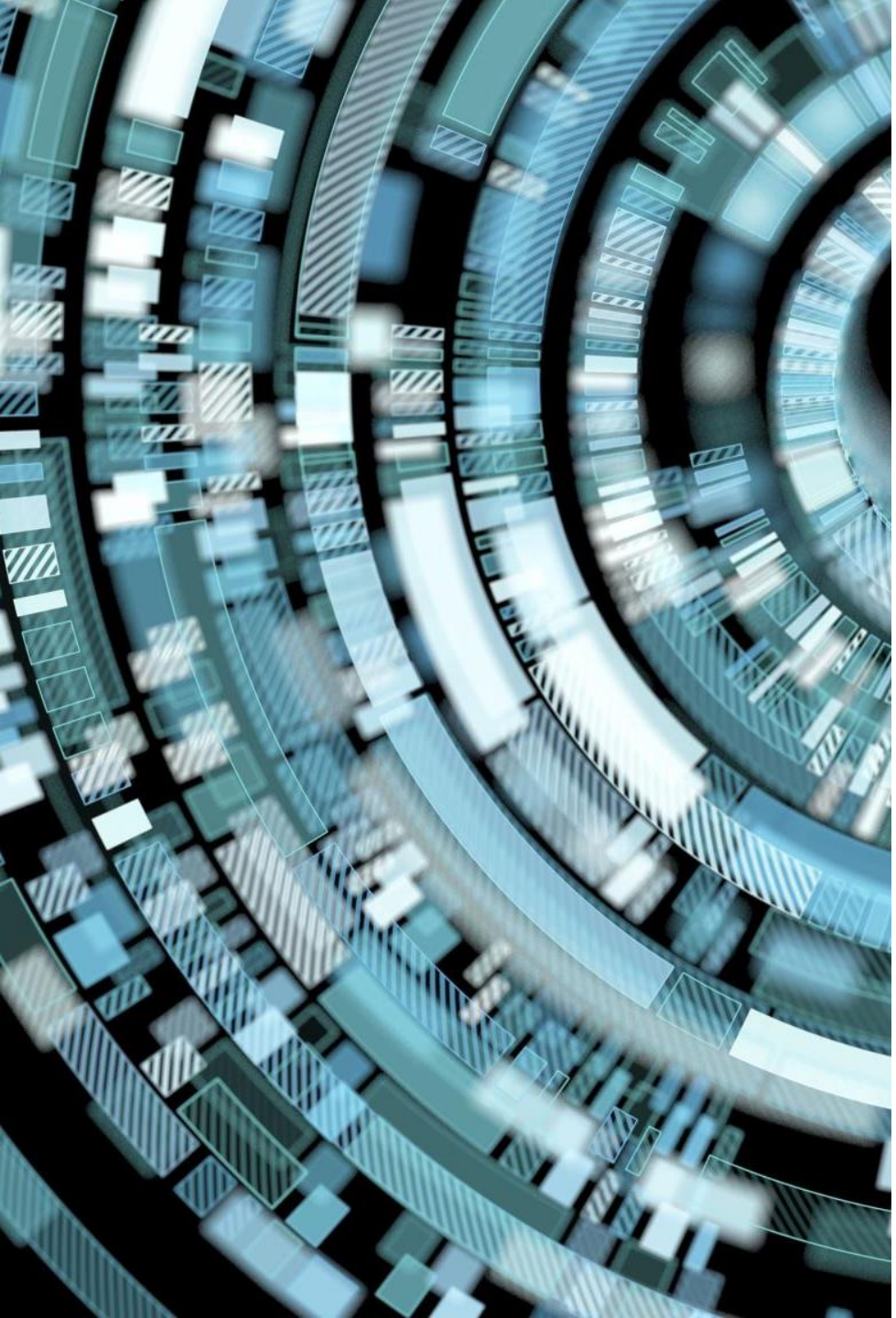


Lecture 13

- Testing
  - Software Testing Overview
  - JUnit Testing
  - Spring Boot Testing
- Logging
  - Logging for Java
  - Logging for Spring Boot

Software Testing

- Software testing is the process of evaluating and verifying that a software product or application does what it is supposed to do.
- It involves execution of software/system components using manual or automated tools to evaluate one or more properties of interest.
- The benefits of testing include preventing bugs, reducing development costs and improving performance.

https://www.ibm.com/topics/software-testing

Types of Software Testing

- **Unit Test (单元测试)**: Test individual method/class in isolation. A unit is the smallest testable component of an application.
- **Integration Test (集成测试)**: Test a group of associated components/classes and ensure that they operate together.
- **System Test (系统测试)**: evaluating a complete software system to ensure that it functions as expected and meets the specified requirements
- **Acceptance Test (验收测试)**: operate on a fully integrated system, testing against the user interface
- **Regression Test (回归测试)**: Tests to ensure that a change does not break the system or introduce new faults.
- ……. (there are more than 150 types of testing types and still adding)

https://www3.ntu.edu.sg/home/ehchua/programming/java/JavaUnitTesting.html

JUnit 5

- JUnit is an open-source Unit Testing Framework for Java
- Initially designed by Erich Gamma and Kent Beck
- JUnit 5
  - JUnit 5 is the latest version and uses the new `org.junit.jupiter` package for its annotations and classes
  - JUnit 5 leverages features from Java 8 or later, such as lambda functions, making tests more powerful and easier to maintain.
  - JUnit 5 has added some very useful new features for describing, organizing, and executing tests

A Simple JUnit Example

```java
public class Calculator {

    static double add(double... operands) {
        return DoubleStream.of(operands)
                .sum();
    }

    static double multiply(double... operands) {
        return DoubleStream.of(operands)
                .reduce(1, (a, b) -> a * b);
    }
}
```

```java
import org.junit.jupiter.api.Test;
import static org.junit.jupiter.api.Assertions.*;

class CalculatorTest {

    @Test
    void add() {
        assertEquals(4, Calculator.add(2, 2));
    }

    @Test
    void multiply() {
        assertAll(() -> assertEquals(4,
                        Calculator.multiply(2, 2)),
                  () -> assertEquals(-4,
                        Calculator.multiply(2, -2)),
                  () -> assertEquals(4,
                        Calculator.multiply(-2, -2)),
                  () -> assertEquals(0,
                        Calculator.multiply(1, 0)));
    }
}
```

Test Class

- Any class that contains at least one test method. Test classes **must not** be abstract and **must** have a single constructor.
- Test classes are not required to be public, but they **must not** be private

```java
import org.junit.jupiter.api.Test;
import static org.junit.jupiter.api.Assertions.*;

class CalculatorTest {

    @Test
    void add() {
        assertEquals(4, Calculator.add(2, 2));
    }

    @Test
    void multiply() {
        assertAll(() -> assertEquals(4,
                        Calculator.multiply(2, 2)),
                  () -> assertEquals(-4,
                        Calculator.multiply(2, -2)),
                  () -> assertEquals(4,
                        Calculator.multiply(-2, -2)),
                  () -> assertEquals(0,
                        Calculator.multiply(1, 0)));
    }
}
```

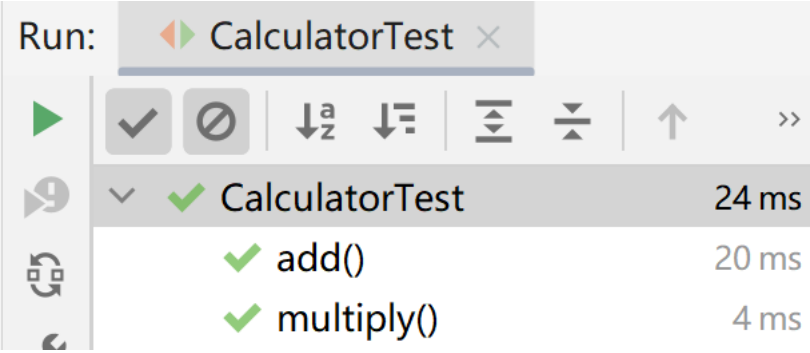
Test Methods

- Any instance method that is annotated with `@Test`, `@RepeatedTest`, `@ParameterizedTest`, `@TestFactory`, or `@TestTemplate`.
- Test methods may be declared locally within the current test class, inherited from superclasses, or inherited from interfaces
- Test methods must **not** be abstract and must **not** return a value (except `@TestFactory` methods which are required to return a value).

```java
import org.junit.jupiter.api.Test;
import static org.junit.jupiter.api.Assertions.*;

class CalculatorTest {

    @Test
    void add() {
        assertEquals(4, Calculator.add(2, 2));
    }

    @Test
    void multiply() {
        assertAll(() -> assertEquals(4,
                        Calculator.multiply(2, 2)),
                  () -> assertEquals(-4,
                        Calculator.multiply(2, -2)),
                  () -> assertEquals(4,
                        Calculator.multiply(-2, -2)),
                  () -> assertEquals(0,
                        Calculator.multiply(1, 0)));
    }
}
```

Test Execution

- Assertions (断言) is a collection of utility methods that support asserting conditions in test methods.
- Run the test class `CalculatorTest` will execute all its test methods




```java
import org.junit.jupiter.api.Test;
import static org.junit.jupiter.api.Assertions.*;

class CalculatorTest {

    @Test
    void add() {
        assertEquals(4, Calculator.add(2, 2));
    }

    @Test
    void multiply() {
        assertAll(() -> assertEquals(4,
                        Calculator.multiply(2, 2)),
                  () -> assertEquals(-4,
                        Calculator.multiply(2, -2)),
                  () -> assertEquals(4,
                        Calculator.multiply(-2, -2)),
                  () -> assertEquals(0,
                        Calculator.multiply(1, 0)));
    }
}
```

Lifecycle Methods

- Any method that is annotated with `@BeforeAll`, `@AfterAll`, `@BeforeEach`, or `@AfterEach`

- `@BeforeEach` is used to signal that the annotated method should be executed before each `@Test` method in the current test class.
- `@BeforeEach` methods must have a void return type, must NOT be private, and must NOT be static

```
class CalculatorTest {

    Calculator c;

    @BeforeEach
    void setUp() {
        c = new Calculator();
    }

    @Test
    void add() {
        assertEquals(4, Calculator.add(2, 2));
    }

    @Test
    void multiply() {
        assertEquals(4, Calculator.multiply(2, 2));
    }

    @AfterEach
    void tearDown() {
        c = null;
    }
}
```

Lifecycle Methods

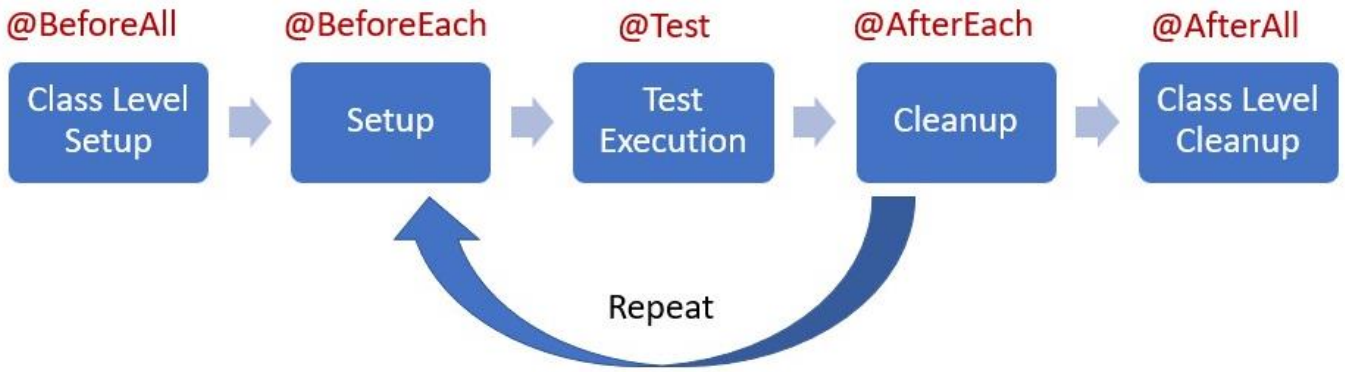
- `@BeforeAll` is used to signal that the annotated method should be **executed before all tests** in the current test class.
- In contrast to `@BeforeEach` methods, `@BeforeAll` methods are **only executed once** for a given test class.
- `@BeforeAll` methods must have a void return type, must not be private, and must be static by default
- Generally, heavy objects like database connections and cleanup are executed in such a class level setup

```java
public class DatabaseTest {
    static Database db;

    @BeforeAll
    public static void initDatabase() {
        db = createDb(...);
    }

    @AfterAll
    public static void dropDatabase() {
        ...
    }
}
```

Test Lifecycle

The complete lifecycle of a test case can be seen in 3 phases

1. **Setup**: This phase puts the test infrastructure in place. JUnit provides class level setup (`@BeforeAll`) and method level setup (`@BeforeEach`). Generally, heavy objects like database connections are created in class level setup while lightweight objects like test objects are reset in the method level setup.
2. **Test Execution**: In this phase, the test execution and assertion happen, and results signify a success or failure.
3. **Cleanup**: This phase is used to cleanup the test infrastructure setup in the first phase. Just like setup, teardown also happen at class level (`@AfterAll`) and method level (`@AfterEach`).

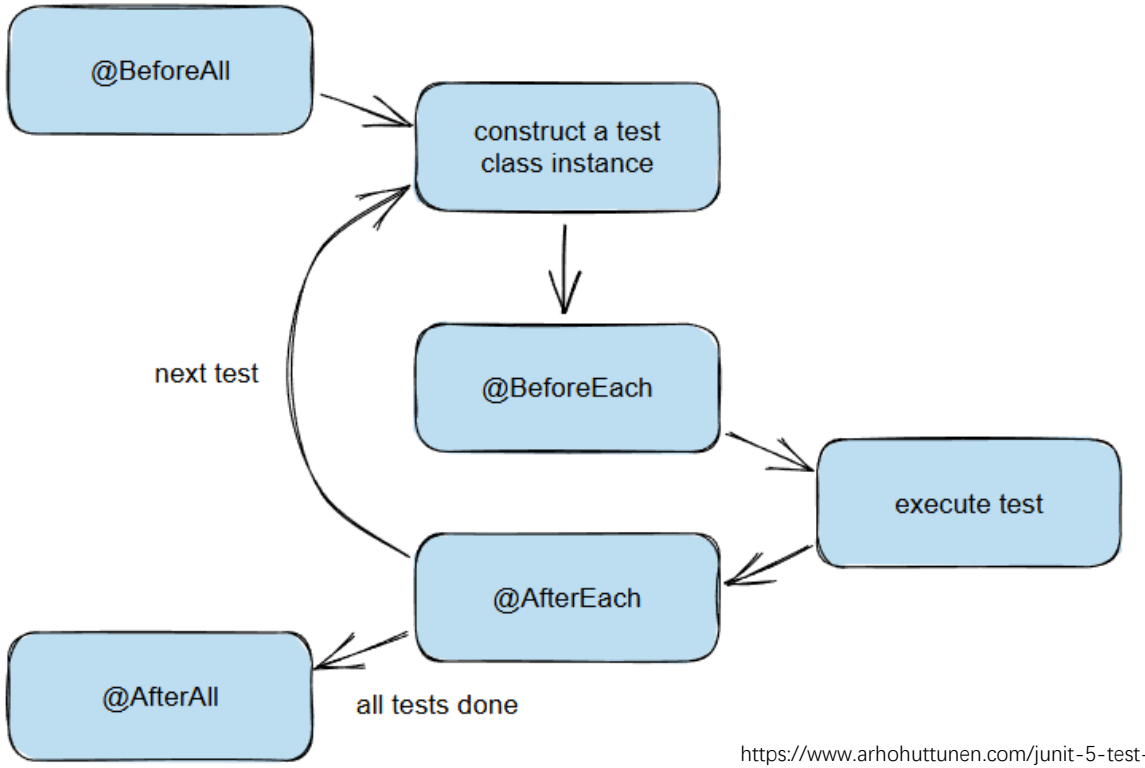


Reference: https://howtodoinjava.com/junit5/junit-5-test-lifecycle/

Test Instance Lifecycle

PER_METHOD

To allow individual test methods to be executed in isolation and to avoid unexpected side effects due to mutable test instance state, JUnit creates a new instance of each test class before executing each test method (the default `PER_METHOD` lifecycle)



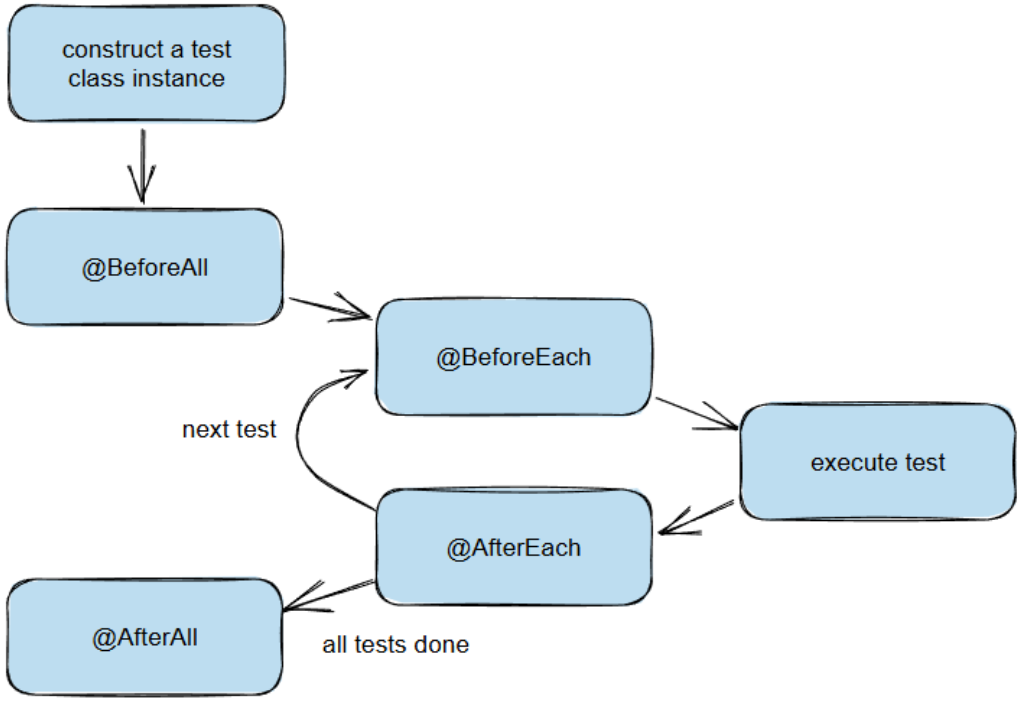
https://www.arhohuttunen.com/junit-5-test-lifecycle/

Test Instance Lifecycle

PER_CLASS

If you prefer that JUnit execute all test methods on the same test instance, annotate your test class with `@TestInstance(Lifecycle.PER_CLASS)`

- A new test instance will be created once per test class.
- If your test methods rely on state stored in instance variables, you may need to reset that state in `@BeforeEach` or `@AfterEach` methods.
- `@BeforeAll` and `@AfterAll` can be non-static in this case



Assertions

```
@Test
void standardAssertions(){
    assertEquals(2, Calculator.add(1,1));

    assertEquals(4, Calculator.multiply(2,2),
                                "Optional failure messages");

    assertTrue(Calculator.add(1,1) == 2);

    assertArrayEquals(new int[]{1,2}, new int[]{1,2,3});

    assertNull(null);

}
```

java.lang.Object
    org.junit.jupiter.api.Assertions

Assertions is a class/collection of utility methods that support asserting conditions in tests.

If one assert fails, the test will stop and you will NOT see the results of the remaining asserts

assertAll

```
public static void assertAll(String heading,
                             Executable... executables)
                      throws MultipleFailuresError
```

Asserts that *all* supplied `executables` do not throw exceptions.

```
Address address = unitUnderTest.methodUnderTest();
assertAll("Should return address of Oracle's headquarter",
    () -> assertEquals("Redwood Shores", address.getCity()),
    () -> assertEquals("Oracle Parkway", address.getStreet()),
    () -> assertEquals("500", address.getNumber())
);
```

```
org.opentest4j.MultipleFailuresError:
    Should return address of Oracle's headquarter (3 failures)
    expected: <Redwood Shores> but was: <Walldorf>
    expected: <Oracle Parkway> but was: <Dietmar-Hopp-Allee>
    expected: <500> but was: <16>
```

If any supplied Executable throws an `AssertionError`, all remaining executables will still be executed, and all failures will be aggregated and reported in a `MultipleFailuresError`.

Example: https://stackoverflow.com/questions/40796756/assertall-vs-multiple-assertions-in-junit5

Assumptions

- Assumptions is a collection of utility methods that support conditional test execution based on assumptions.
- In contrast to failed assertions, which result in a test failure, a failed assumption results in a test being *aborted*.
- Assumptions are typically used whenever it does not make sense to continue execution of a given test method (e.g., if the test depends on something that does not exist in the current runtime environment)

https://junit.org/junit5/docs/5.0.0/api/org/junit/jupiter/api/Assumptions.html

Assumptions

```java
private final Calculator calculator = new Calculator();

@Test
void testOnlyOnCiServer() {
    assumeTrue("CI".equals(System.getenv("ENV")));
    // remainder of test
}

@Test
void testOnlyOnDeveloperWorkstation() {
    assumeTrue("DEV".equals(System.getenv("ENV")),
        () -> "Aborting test: not on developer workstation");
    // remainder of test
}

@Test
void testInAllEnvironments() {
    assumingThat("CI".equals(System.getenv("ENV")),
        () -> {
            // perform these assertions only on the CI server
            assertEquals(2, calculator.divide(4, 2));
        });

    // perform these assertions in all environments
    assertEquals(42, calculator.multiply(6, 7));
}
```

https://junit.org/junit5/docs/current/user-guide/#writing-tests-assumptions

Conditional Test Execution

- Entire test classes or individual test methods may be disabled via the `@Disabled` annotation

```java
@Target({ElementType.TYPE, ElementType.METHOD})
@Retention(RetentionPolicy.RUNTIME)
@Documented
@API(
    status = Status.STABLE,
    since = "5.0"
)
public @interface Disabled {
    String value() default "";
}
```

- Developers could either enable or disable a test based on certain conditions programmatically

```java
@Test
@EnabledOnOs({ LINUX, MAC })
void onLinuxOrMac() {
    // ...
}

@Test
@DisabledOnOs(WINDOWS)
void notOnWindows() {
    // ...
}
```

```java
@Test
@EnabledForJreRange(min = JAVA_9, max = JAVA_11)
void fromJava9to11() {
    // ...
}
```

```java
@Test
@DisabledForJreRange(min = JAVA_9)
void notFromJava9toCurrentJavaFeatureNumber() {
    // ...
}
```

https://junit.org/junit5/docs/current/user-guide/#writing-tests-conditional-execution

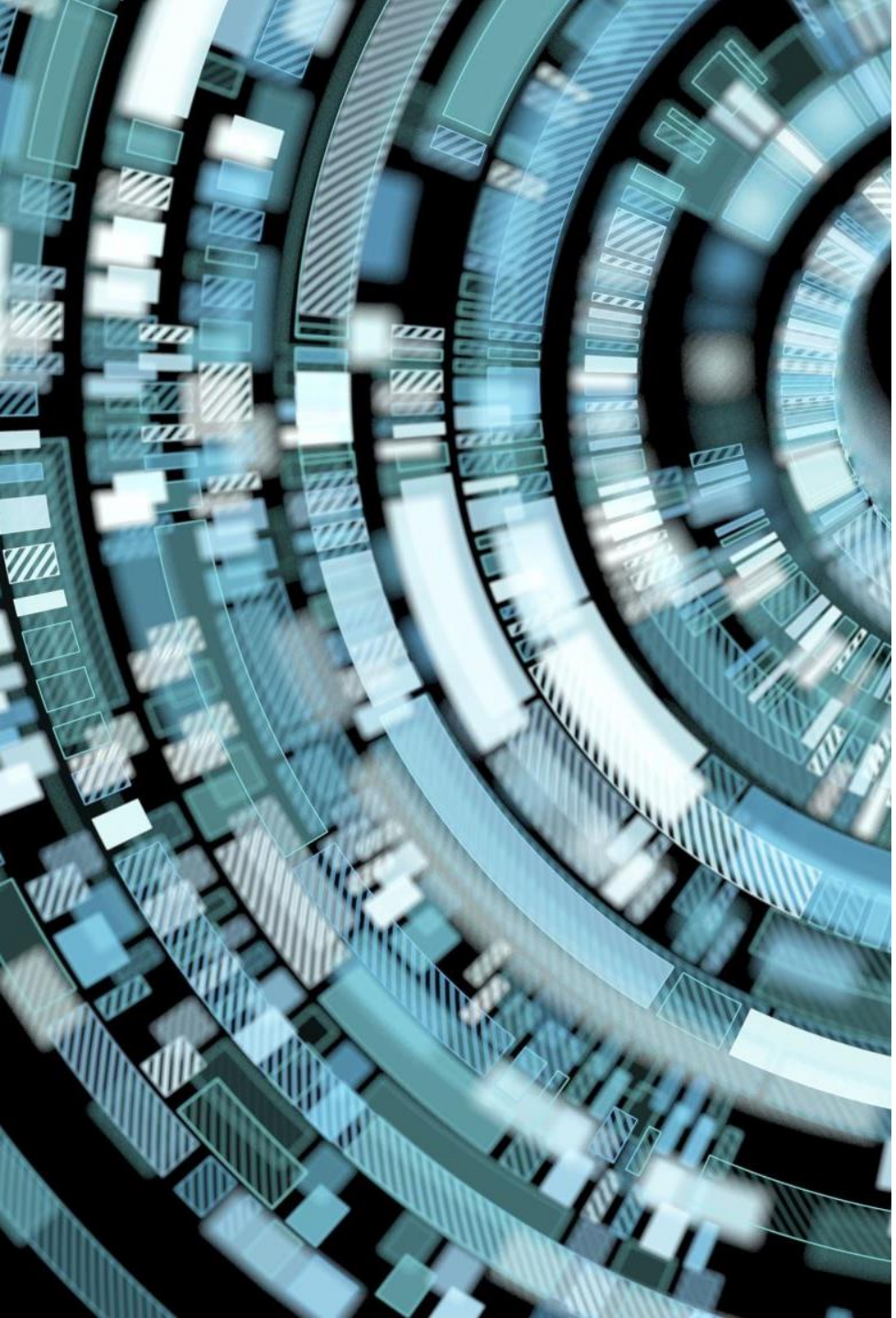
Parameterized Test

- Parameterized tests make it possible to run a test multiple times with different arguments.
- Use the `@ParameterizedTest` annotation
- You must declare at least one source that will provide the arguments for each invocation and then consume the arguments in the test method.

```java
@ParameterizedTest
@ValueSource(strings = { "racecar", "radar", "able was I ere I saw elba" })
void palindromes(String candidate) {
    assertTrue(StringUtils.isPalindrome(candidate));
}
```

```
palindromes(String) ✓
├─ [1] candidate=racecar ✓
├─ [2] candidate=radar ✓
└─ [3] candidate=able was I ere I saw elba ✓
```

https://junit.org/junit5/docs/current/user-guide/#writing-tests-parameterized-tests



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Preparation

- Finished Lab 13 (and understand it)
- Add 2 services to be tested
  - `getOneStudent(Long studentId)`
  - `addOneStudent(Student student)`

```java
@Service
public class StudentService {
    7 usages
    private final StudentRepository studentRepository;

    yidatao
    @Autowired
    public StudentService(StudentRepository studentRepository) {
        this.studentRepository = studentRepository;
    }

    1 usage   yidatao
    public Student getOneStudent(Long studentId){
        return studentRepository.findById(studentId).get();
    }

    1 usage   yidatao
    public void addOneStudent(Student student){
        studentRepository.save(student);
    }

    2 usages   yidatao
    public List<Student> getStudents(){
        return studentRepository.findAll();
    }
```

①

②

Preparation

Add 2 corresponding REST endpoints

- `GET /api/students/getOne/{id}`
- `POST /api/students/save`

```java
@RestController
@RequestMapping("/api/students")
public class StudentRestController {
    6 usages
    private final StudentService studentService;

    yidatao
    public StudentRestController(StudentService studentService) {
        this.studentService = studentService;
    }

    yidatao
    @GetMapping("/getOne/{id}")
    public Student getOneStudent(@PathVariable("id") Long studentId){
        return studentService.getOneStudent(studentId);
    }

    yidatao
    @PostMapping("/save")
    public String addOneStudent(@RequestBody Student student){
        studentService.addOneStudent(student);
        return "success";
    }

    yidatao
    @GetMapping
    public List<Student> getStudentsByEmail(@RequestParam(value = "email")
                                            Optional<String> email) {
        if (email.isPresent()){
            return studentService.findByEmailLike(email.get());
        }
        return studentService.getStudents();
    }
```

①

②

Preparation

Manually test the new features

```
GET http://localhost:8080/api/students/getOne/1
```

```
http://localhost:8080/api/students/getOne/1

HTTP/1.1 200
Transfer-Encoding: chunked
Connection: keep-alive
Content-Type: application/json
Date: Thu, 11 May 2023 03:29:59 GMT
Keep-Alive: timeout=4
Proxy-Connection: keep-alive

{
  "id": 1,
  "name": "Mary",
  "email": "mary@gmail.com"
}
Response file saved.
> 2023-05-11T112959.200.json

Response code: 200; Time: 114ms; Content length: 47 bytes
```

```
POST http://localhost:8080/api/students/save
Content-Type: application/json

{"name": "zoe", "email": "zoe@sustech.edu.cn"}
```

```
http://localhost:8080/api/students/save

HTTP/1.1 200
Content-Length: 7
Connection: keep-alive
Content-Type: text/plain;charset=UTF-8
Date: Thu, 11 May 2023 03:58:42 GMT
Keep-Alive: timeout=4
Proxy-Connection: keep-alive

success

Response code: 200; Time: 20ms; Content length: 7 bytes
```

However, to give yourself more confidence that the application works when you make changes, you want to automate the testing.

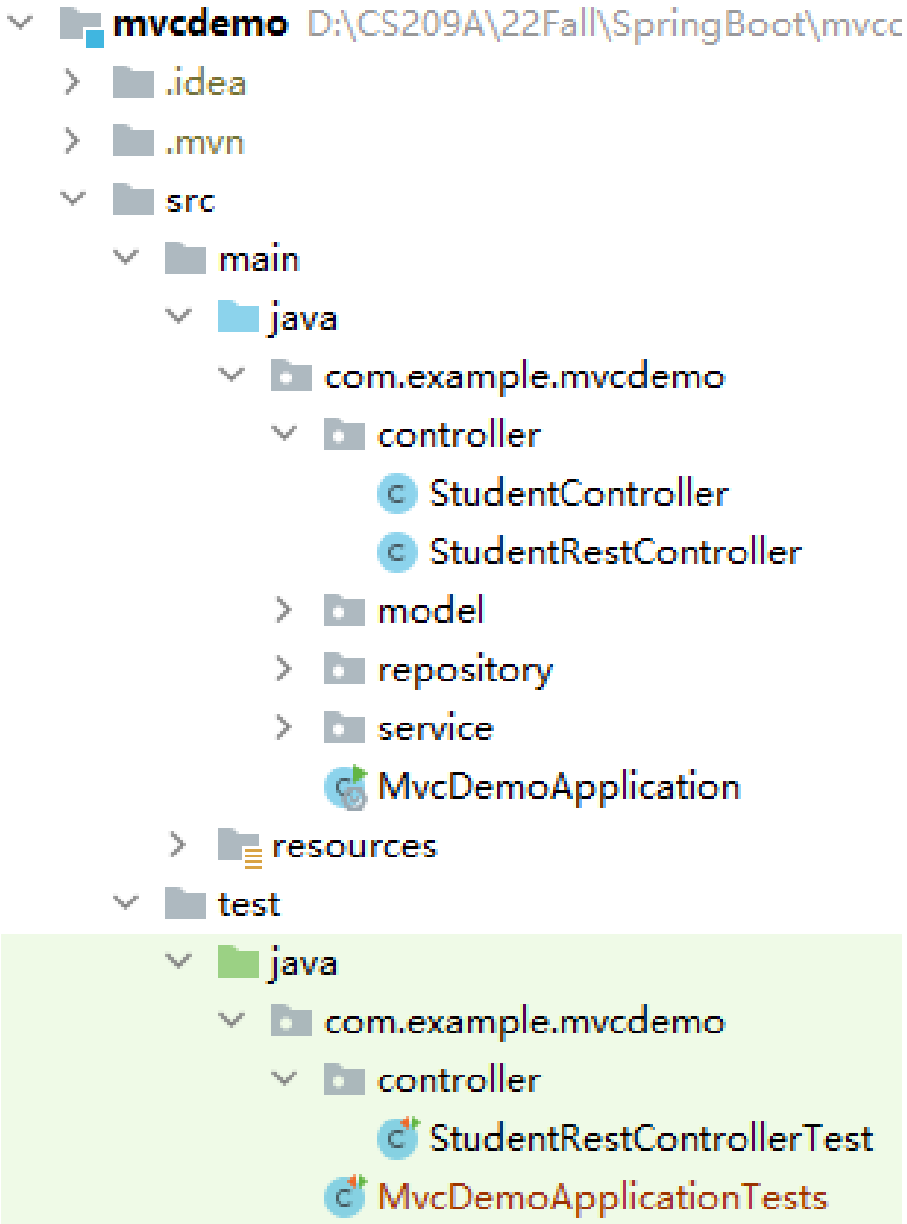
```
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-test</artifactId>
    <scope>test</scope>
</dependency>
```

Convention over Configuration

Spring Boot assumes you plan to test your application, so it adds the necessary dependencies to your pom.xml

Test Structure

Tests will be organized using the same directory structure as the source



Sanity Check

- A basic test or verification of a system or application's fundamental functionality
- The `@SpringBootTest` annotation tells Spring Boot to look for a main configuration class (one with `@SpringBootApplication`) and use that to start a Spring application context

```java
@SpringBootTest
class MvcDemoApplicationTests {

    @Test
    void contextLoads() {
    }

}
```

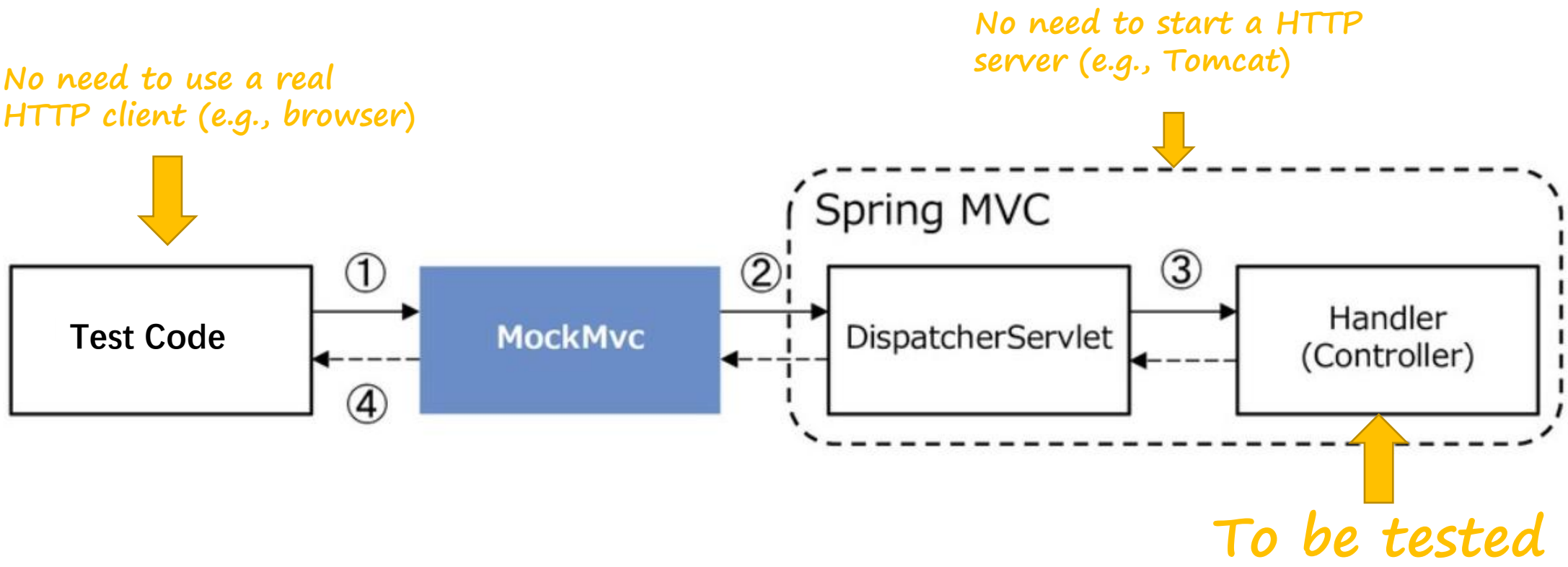
Sanity Check

- To convince yourself that the context is indeed creating your controller, you could add an assertion

```
@SpringBootTest
class MvcDemoApplicationTests {

    1 usage
    @Autowired
    private StudentController controller;

    @Test
    void contextLoads() {
        assertThat(controller).isNotNull();
    }

}
```

Unit Test the Controller

- We want to unit test the controller (web layer) to check
  - URL mapping
  - Correctly handle incoming HTTP request
  - Correctly return HTTP response
- This means we need to start a web server and expose a port, which is
  - Slow
  - Dependent on network conditions



https://speakerdeck.com/rshindo/spring-fest-2020?slide=34

Spring MockMvc

① Test code: Set HTTP request URL and parameters

② MockMvc mocks (模拟) a HTTP request and send it to DispatcherServlet, without having to use a browser or start a server

③ DispatcherServlet invokes the proper controller/handler

④ Test code use MockMvc to assert the response

Test Case

- `@AutoConfigureMockMvc` is a Spring Boot annotation that automatically configures a `MockMvc` instance in a test class.

```java
@SpringBootTest
@AutoConfigureMockMvc
class StudentRestControllerTest {
    5 usages
    @Autowired
    private MockMvc mvc;

    yidatao
    @Test
    void getOneStudent() throws Exception {
        mvc.perform(get( urlTemplate: "/api/students/getOne/{id}", ...uriVars: 1))
                .andExpect(status().isOk())
                .andExpect(jsonPath( expression: "$.name").value( expectedValue: "Mary"))
                .andDo(print());
    }
```

Test Case

- `MockMvc.perform()`: contruct HTTP requests
- `MockMvc.andExpect()`: assert that the response meets the expection (e.g., status, response content type, response body, etc.)

```
@SpringBootTest
@AutoConfigureMockMvc
class StudentRestControllerTest {
    5 usages
    @Autowired
    private MockMvc mvc;

    yidatao
    @Test
    void getOneStudent() throws Exception {
        mvc.perform(get( urlTemplate: "/api/students/getOne/{id}", ...uriVars: 1))
                .andExpect(status().isOk())
                .andExpect(jsonPath( expression: "$.name").value( expectedValue: "Mary"))
                .andDo(print());
    }
```

```java
@Test
void getStudentsByEmail() throws Exception {
    mvc.perform(get( urlTemplate: "/api/students/?email={email}",  ...uriVars: "jack")).
            andExpect(status().isOk()).
            andExpect(jsonPath( expression: "$.*", hasSize(1))). // ensure 1 student matches
            andExpect(jsonPath( expression: "$.[0].name").value( expectedValue: "Jack")). // verify
            andDo(print());
}
```

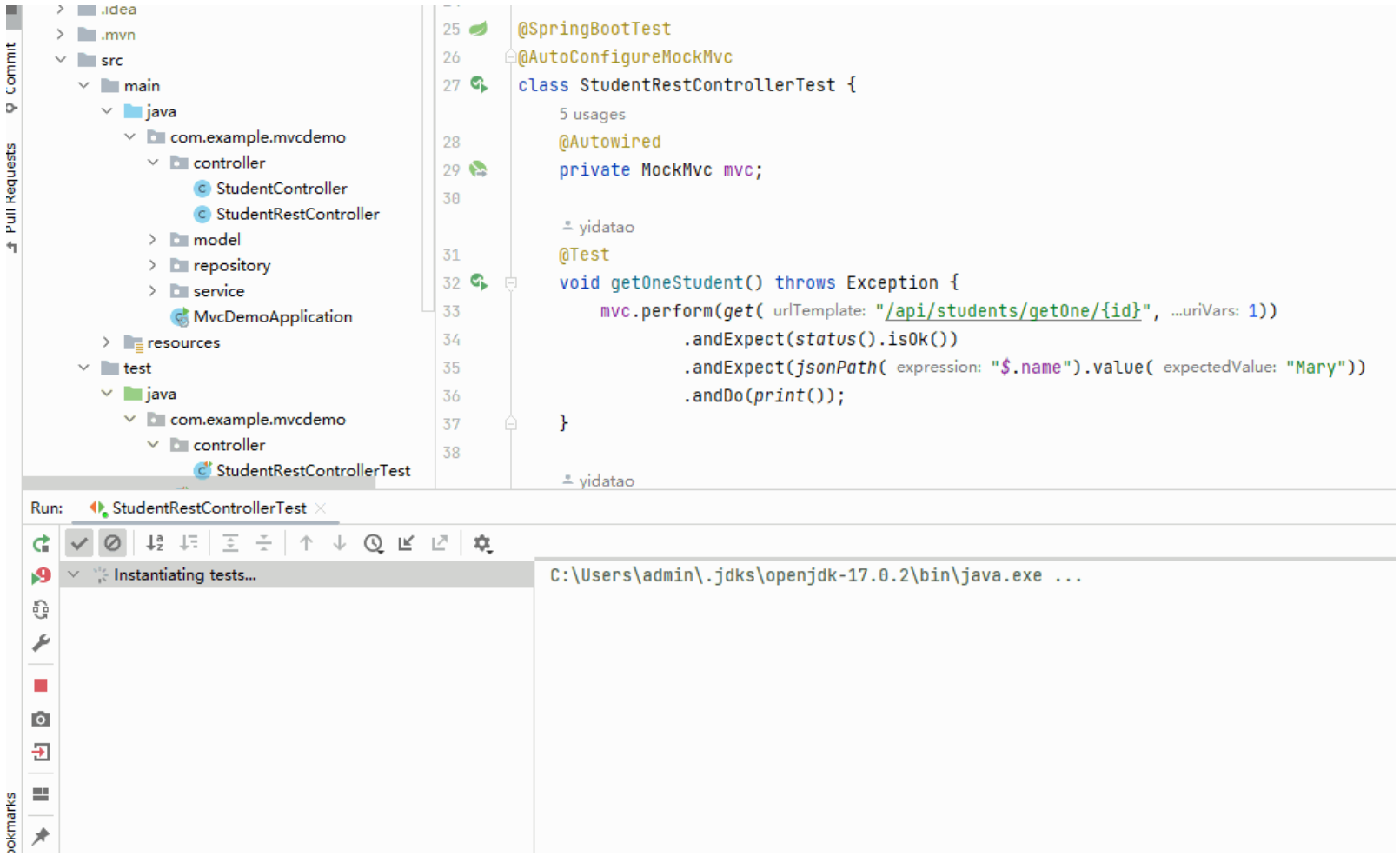
JsonPath

- JsonPath is used for querying and manipulating JSON data
- It provides a simple and intuitive syntax for accessing values in a JSON document
- It can be used to assert and verify JSON responses in unit tests

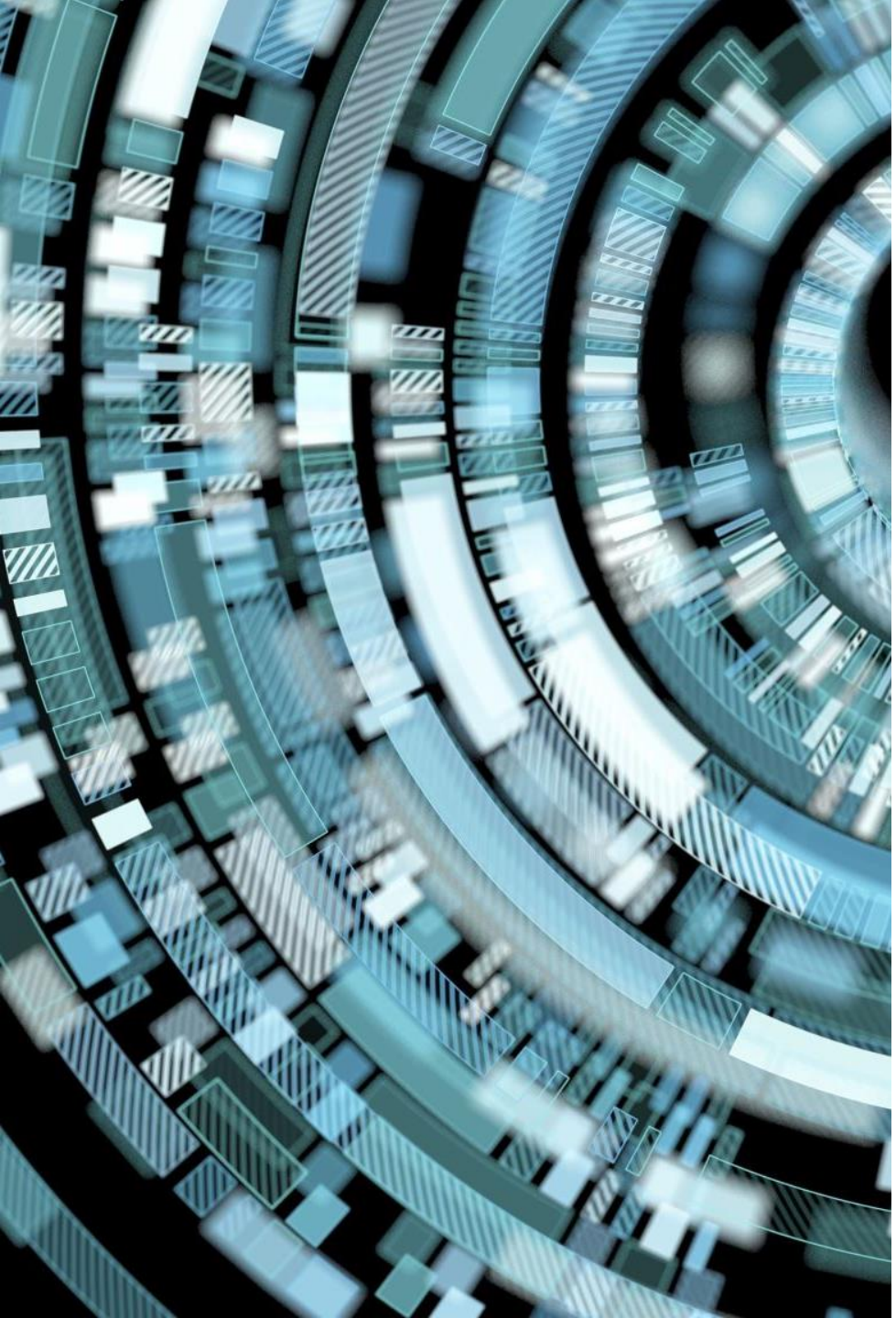
Test Case

- `ObjectMapper` supports transformation between Objects and JSON strings
- Can be used to test `POST` requests, which requires a JSON string as request body

```java
@Test
void addOneStudent() throws Exception {
    Student stu = new Student( name: "Jack",  email: "jack@mail.com");
    ObjectMapper mapper = new ObjectMapper();

    // convert user to JSON
    String json = mapper.writeValueAsString(stu);

    // send POST request to create user
    mvc.perform(post( urlTemplate: "/api/students/save")
                    .contentType(MediaType.APPLICATION_JSON)
                    .content(json))
            .andExpect(status().isOk());

    // verify that user was indeed created
    mvc.perform(get( urlTemplate: "/api/students/getOne/{id}", ...uriVars: 4))
            .andExpect(status().isOk())
            .andExpect(jsonPath( expression: "$.name", is(stu.getName())))
            .andExpect(jsonPath( expression: "$.email", is(stu.getEmail())));
}
```



Executing Tests



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What is Logging (日志)?

Logging in Java refers to the process of recording information, events, or errors that occur during the execution of a program.

Why Logging Matters?

- Troubleshooting
- Monitoring
- Performance optimization
- Security
- Historical analysis

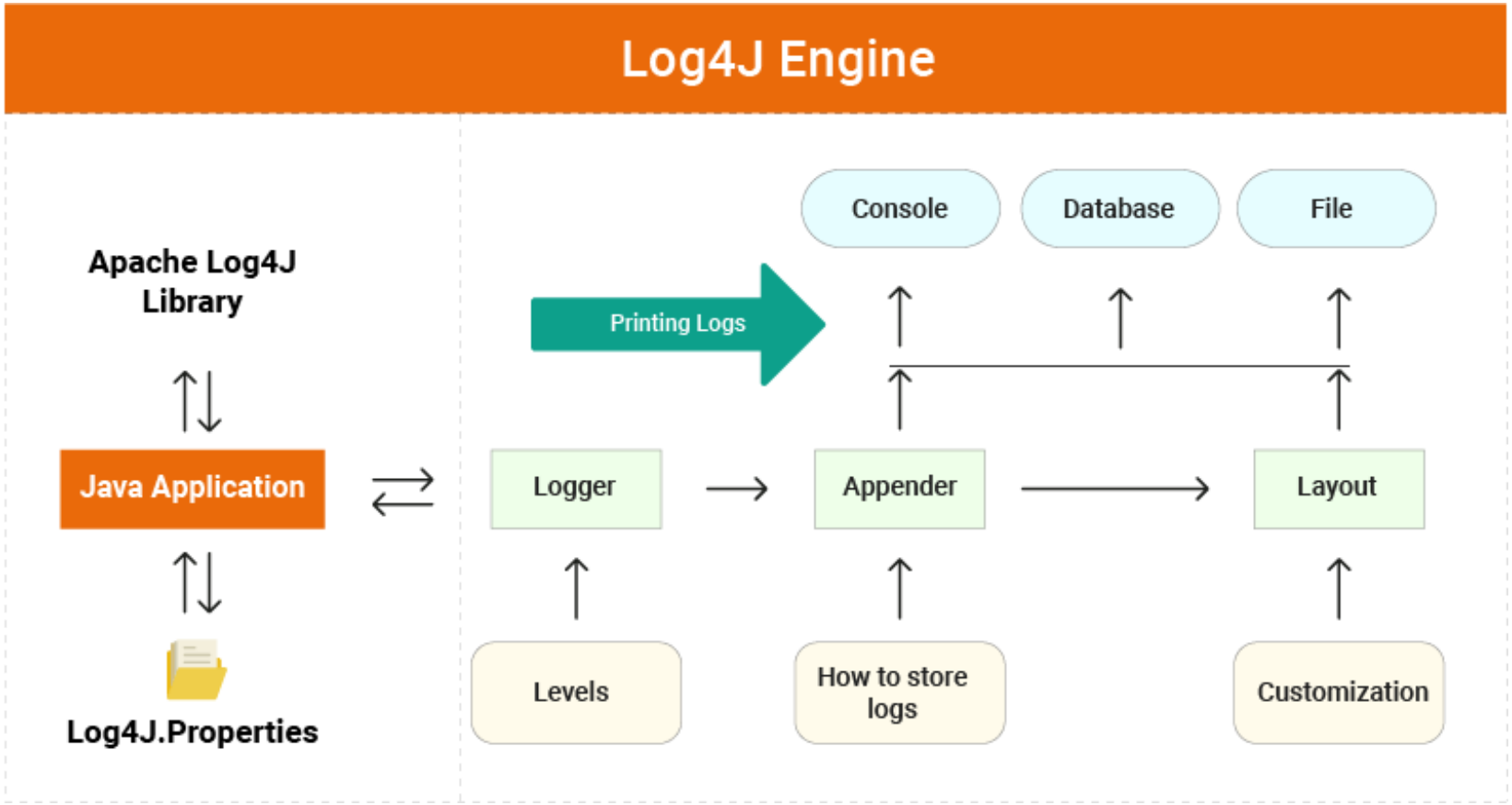
Logging with `system.out.println`

- Every Java programmer is familiar with inserting calls to `System.out.println` into troublesome code to gain insight into program behavior.
- Of course, once you have figured out the cause of trouble, you remove the print statements, only to put them back in when the next problem surfaces.
- Performance could be affected for many `println()`
- All things will be printed with no filter (flooded console)

Java's logging API is designed to overcome this problem!

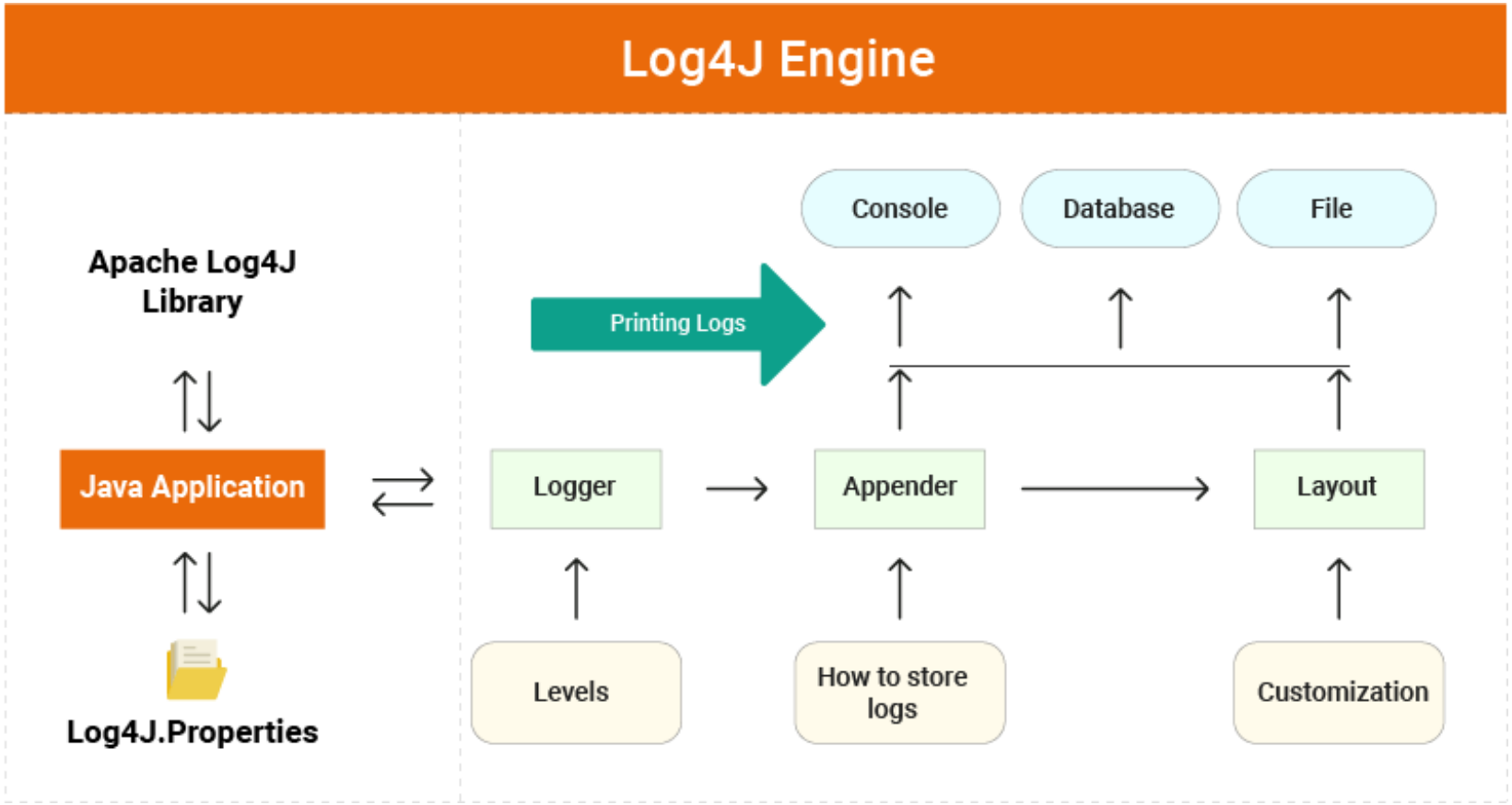
Requirements for Logging

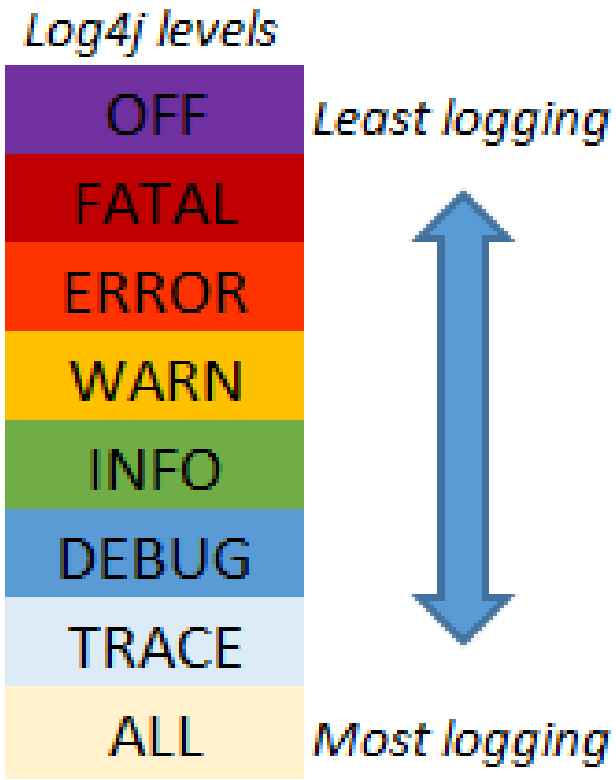
1	2	3	4
Logs can have different formats: plain text, XML, HTML, etc.	Logs can be handled differently: display in consoles, save to files, etc.	Logs can have different levels and different filters.	Application can have different logging mechanisms for different classes and packages.



A **logger** is a named entity in Log4j that is responsible for capturing and processing log messages.

Apache Log4j





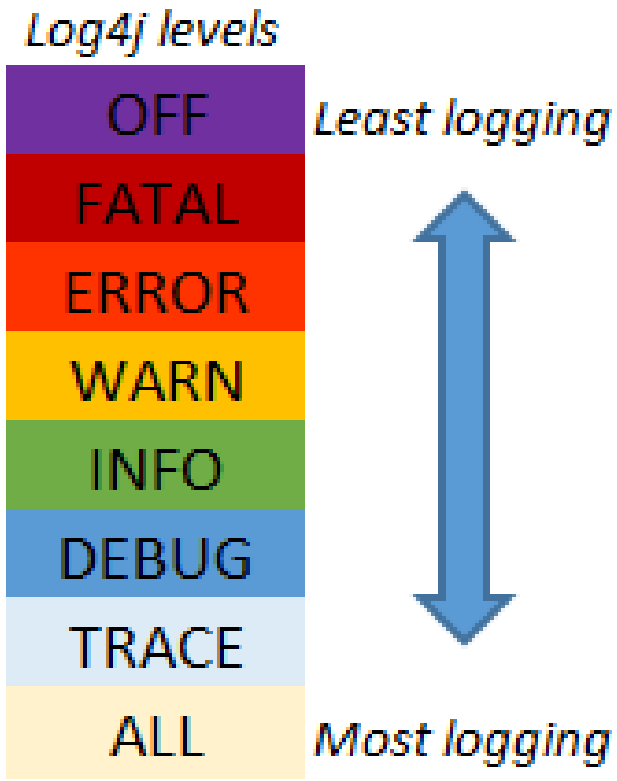
Apache Log4j

Authentication Module

```
INFO : User alice logged in.
WARN : User bob entered an invalid password.
ERROR: User bob entered an invalid password three times, user locked out.
```

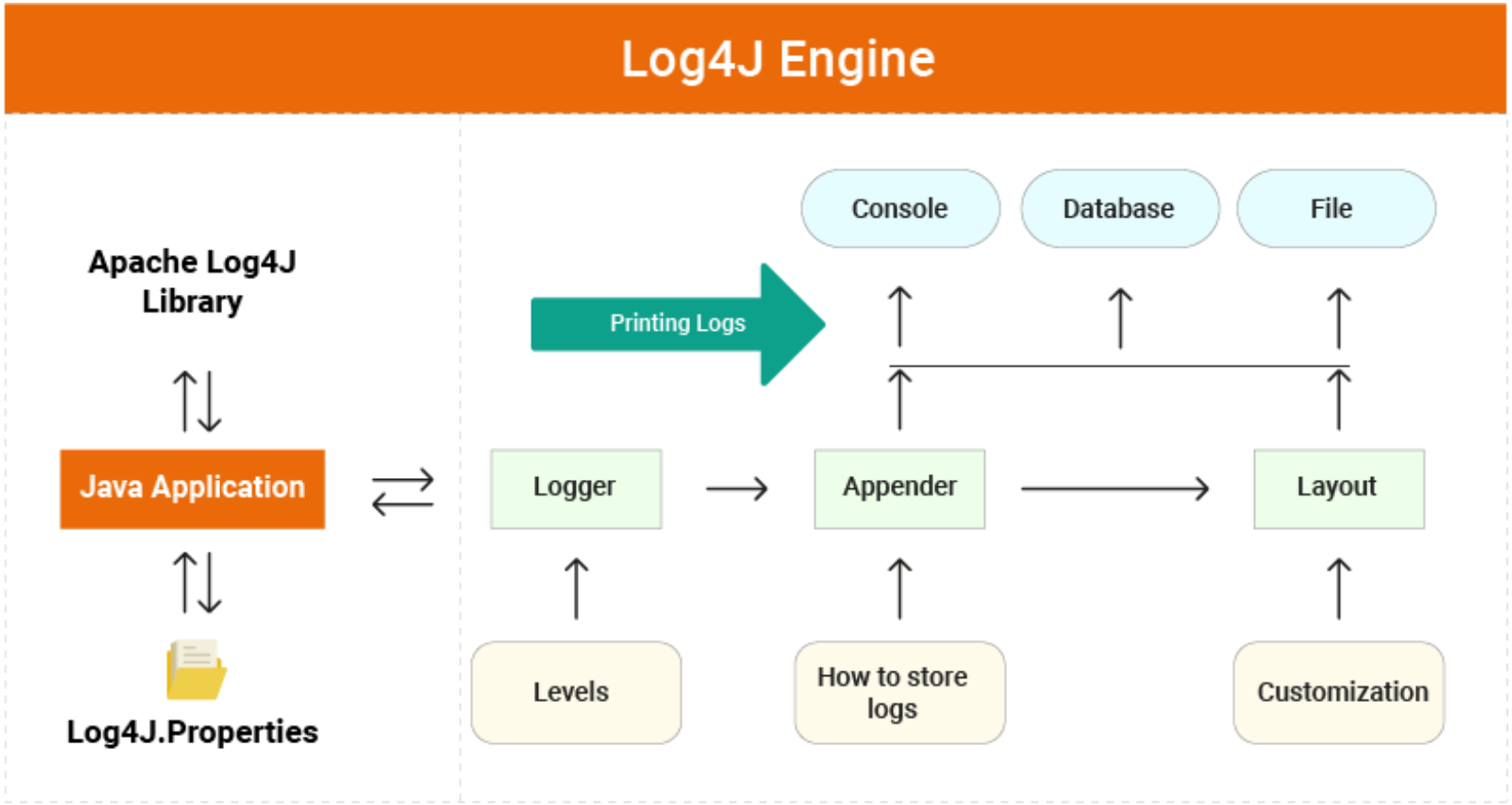
Email Agent

```
DEBUG: Loading user bob from database jdbc:...
INFO : Emailed user bob: three login attempts rejected, user locked out.
ERROR: Email to alice bounced back; subject: Your weekly summary.
```



https://garygregory.wordpress.com/2015/09/10/the-art-of-test-driven-development-understanding-logging/

Apache Log4j



- **Appenders** are responsible for outputting log messages to various destinations, such as the console, files, databases, or remote servers.
- Log4j provides a variety of built-in appenders, and users can also create custom appenders to suit their specific needs.

Apache Log4j

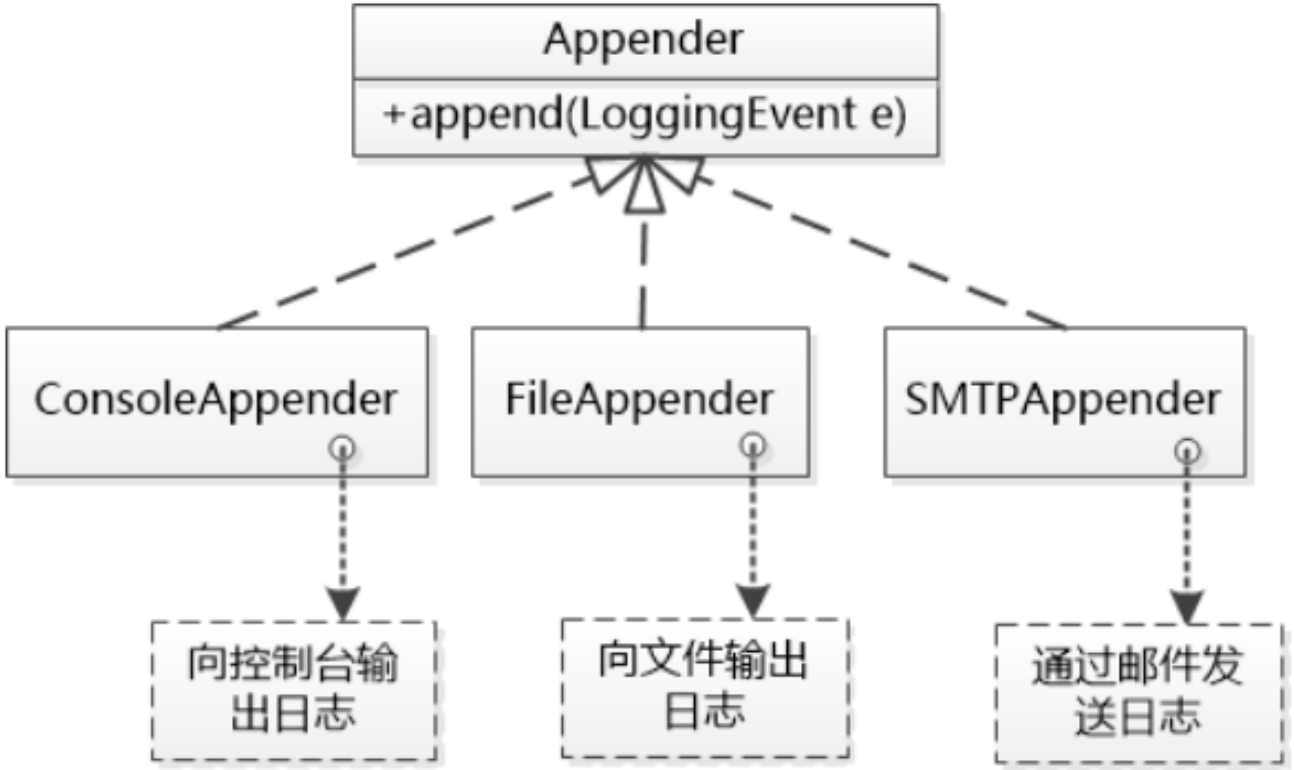


Image source:《码农翻身》刘欣

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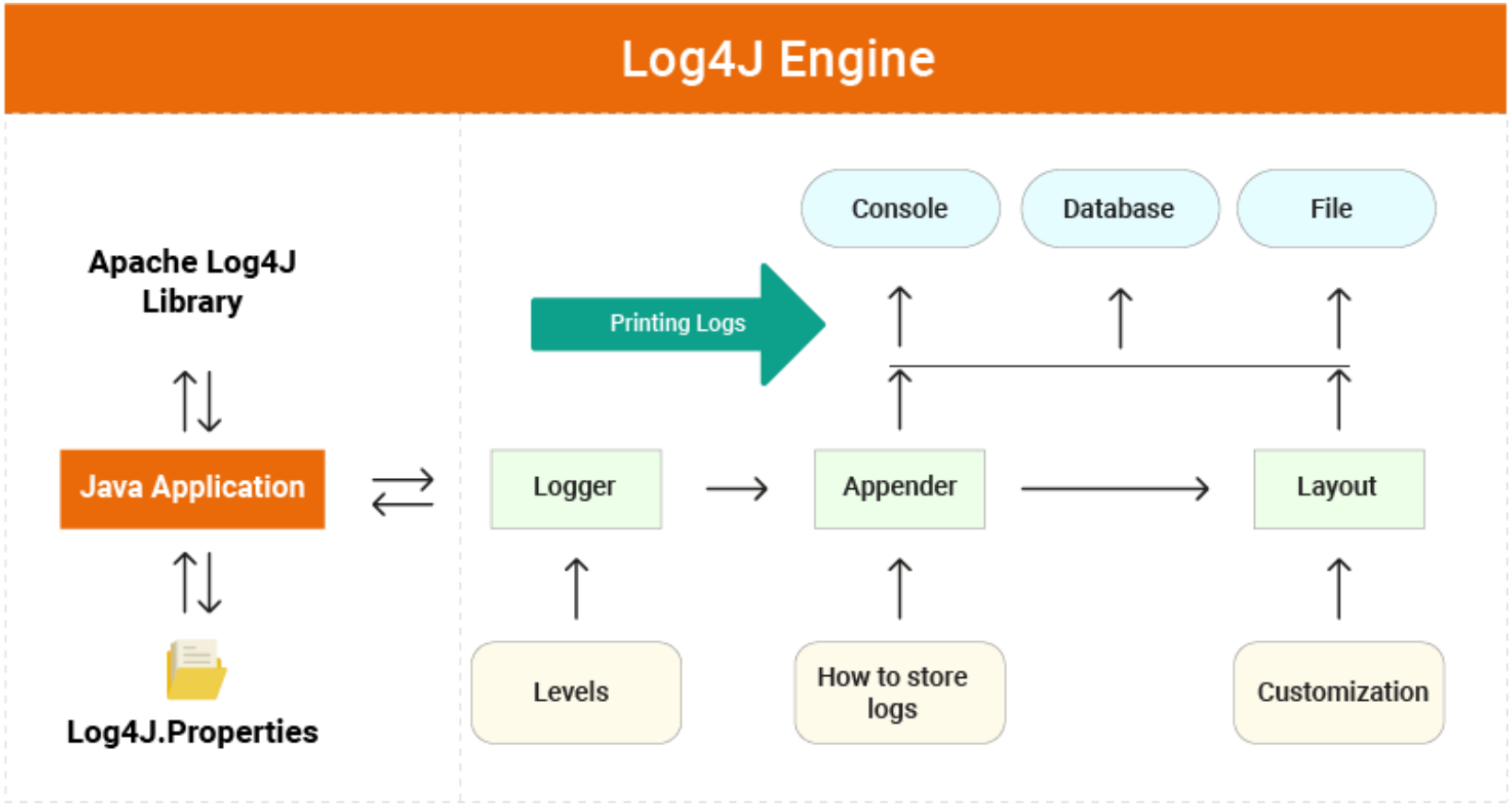
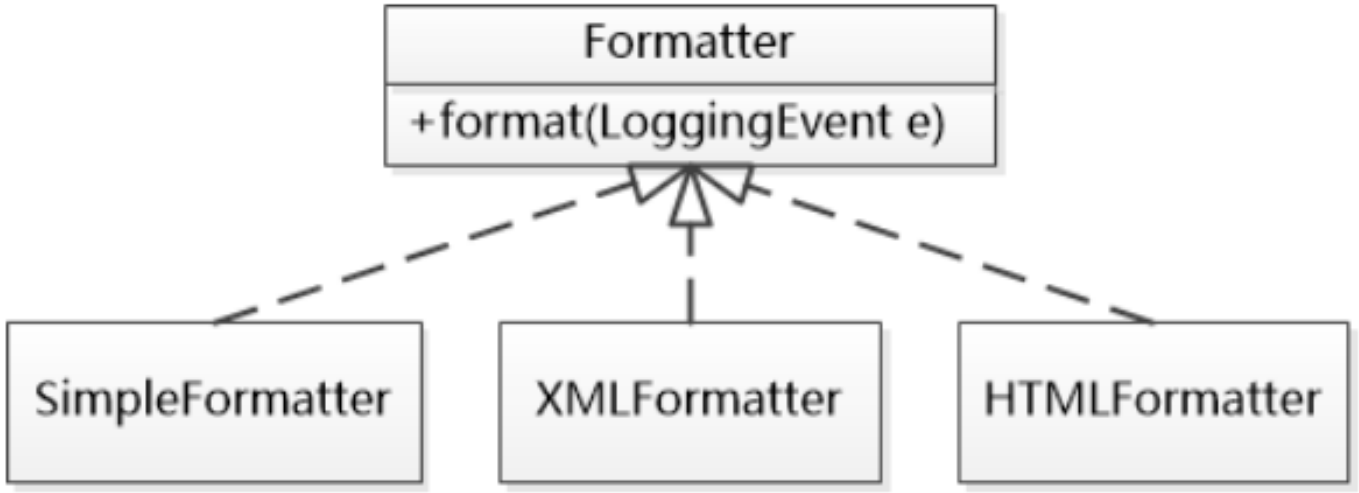
Apache Log4j



A **layout (formatter)** defines the format of log messages. Common layouts include simple text, HTML, and XML formats.

Apache Log4j



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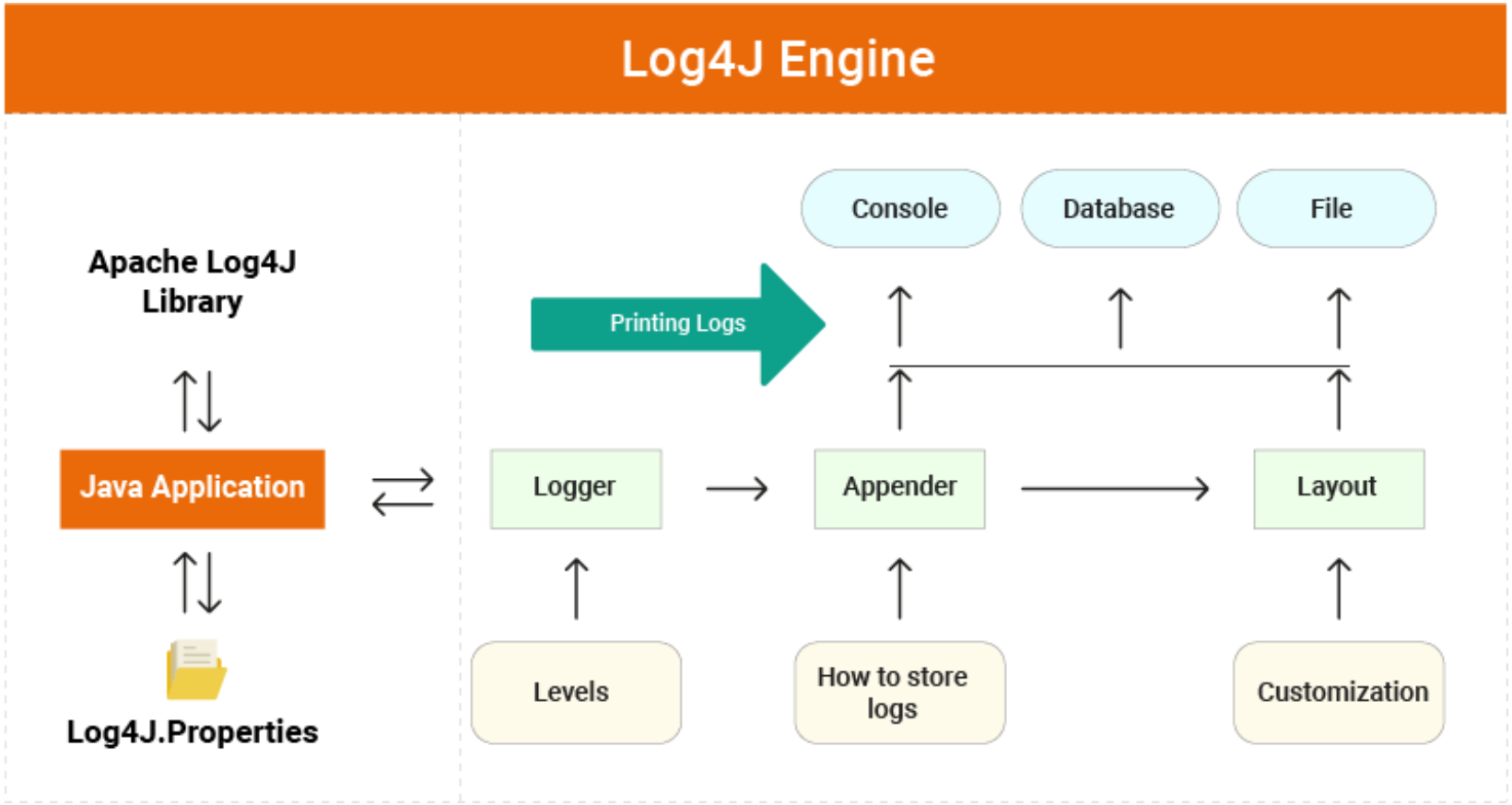
Apache Log4j



- The **log4j.properties** file is a log4j configuration file which stores properties in key-value pairs.
- This file contains the entire runtime configuration used by log4j, such as appenders information, log level information and output file names for file appenders.

Apache Log4j

```
log4j.rootLogger=日志等级， AppenderNameA, ,,,
log4j.appender.AppenderNameA=要使用的Appender
log4j.appender.AppenderNameA.PropertyA=PropertyA的值
log4j.appender.AppenderNameA.PropertyB=PropertyB的值
log4j.appender.AppenderNameA.PropertyC=PropertyC的值

log4j.appender.AppenderNameA.layout=要使用的Layout
log4j.appender.AppenderNameA.layout.PropertyA=PropertyA的值
log4j.appender.AppenderNameA.layout.PropertyB=PropertyB的值
log4j.appender.AppenderNameA.layout.PropertyC=PropertyC的值
```

```
log4j.rootLogger=debug,cons

log4j.appender.cons=org.apache.log4j.ConsoleAppender
log4j.appender.cons.target=System.out
log4j.appender.cons.layout=org.apache.log4j.PatternLayout
log4j.appender.cons.layout.ConversionPattern=%m%n
```

Image source: https://zhuanlan.zhihu.com/p/138026497

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- This file contains the entire runtime configuration used by log4j, such as appenders information, log level information and output file names for file appenders.

Apache Log4j

```
#  ================================ 控制台 日志记录 ================================
log4j.appender.cons=org.apache.log4j.ConsoleAppender
# 设置当前appender的日志等级为info，当方法的优先级大于info时， 控制台才会有输出
log4j.appender.cons.threshold=info
# 设置日志输出方式， System.out 和 System.err 两种选择
log4j.appender.cons.target=System.out
# 设置为true，表示创建新的System.out 对象， 不使用System类中的out属性
log4j.appender.cons.follow=true
log4j.appender.cons.layout=org.apache.log4j.SimpleLayout
```

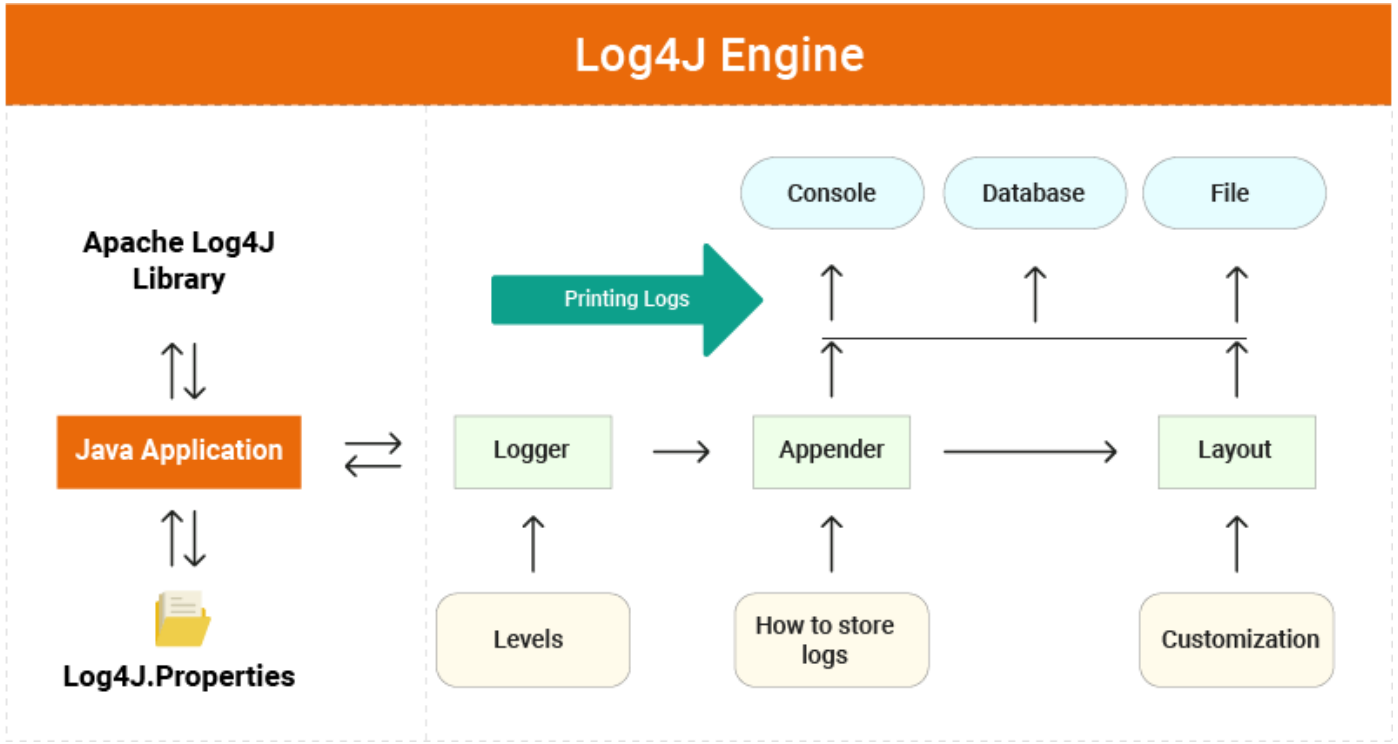
```
#  ================================ 文件 日志记录 ================================
log4j.appender.myFile=org.apache.log4j.FileAppender
# 文件存储路径
log4j.appender.myFile.file=./log.txt
# 是否以追加的形式向日志文件中写入内容， 默认为true，不会覆盖之前的内容， 否则只会保留最后一次写
log4j.appender.myFile.append=false
log4j.appender.myFile.layout=org.apache.log4j.SimpleLayout
```

Image source: https://zhuanlan.zhihu.com/p/138026497

```
#  ================================ 滚动文件 日志记录 ================================
# 当日志达到一定大小时， 将重新创建新文件记录日志
log4j.appender.myrFile=org.apache.log4j.RollingFileAppender
log4j.appender.myrFile.file=./log.txt
# 最多备份文件的个数，当文件大小超过设置的值时， 会将原内容进行备份。
# 该值指定了备份文件的个数， 如果超过数量， 则会删除掉最早的备份文件， 如果为0 则不进行备份
log4j.appender.myrFile.maxBackupIndex=5
# 每个文件的最大容量  默认单位是b， 可以指定 "KB", "MB" 或者 "GB"， 当文件超过该大小时， 会将其
log4j.appender.myrFile.maxFileSize=1024
# 每个文件的最大容量，类似于 maxFileSize， 不过是long类型， 即不可有单位， 单位是b
log4j.appender.myrFile.maximumFileSize=1024
log4j.appender.myrFile.layout=org.apache.log4j.SimpleLayout
```

```
#  ================================ 每日滚动文件 日志记录 ================================
# 日志按天进行备份
log4j.appender.mydFile=org.apache.log4j.DailyRollingFileAppender
# 前一天日志的备份文件的后缀格式（后缀为前一天日期，格式为日期格式）
log4j.appender.mydFile.datePattern=yyyyMMdd
# 当天的日志的记录文件路径
log4j.appender.mydFile.file=./nl.txt
log4j.appender.mydFile.layout=org.apache.log4j.SimpleLayout
```

Apache Log4j



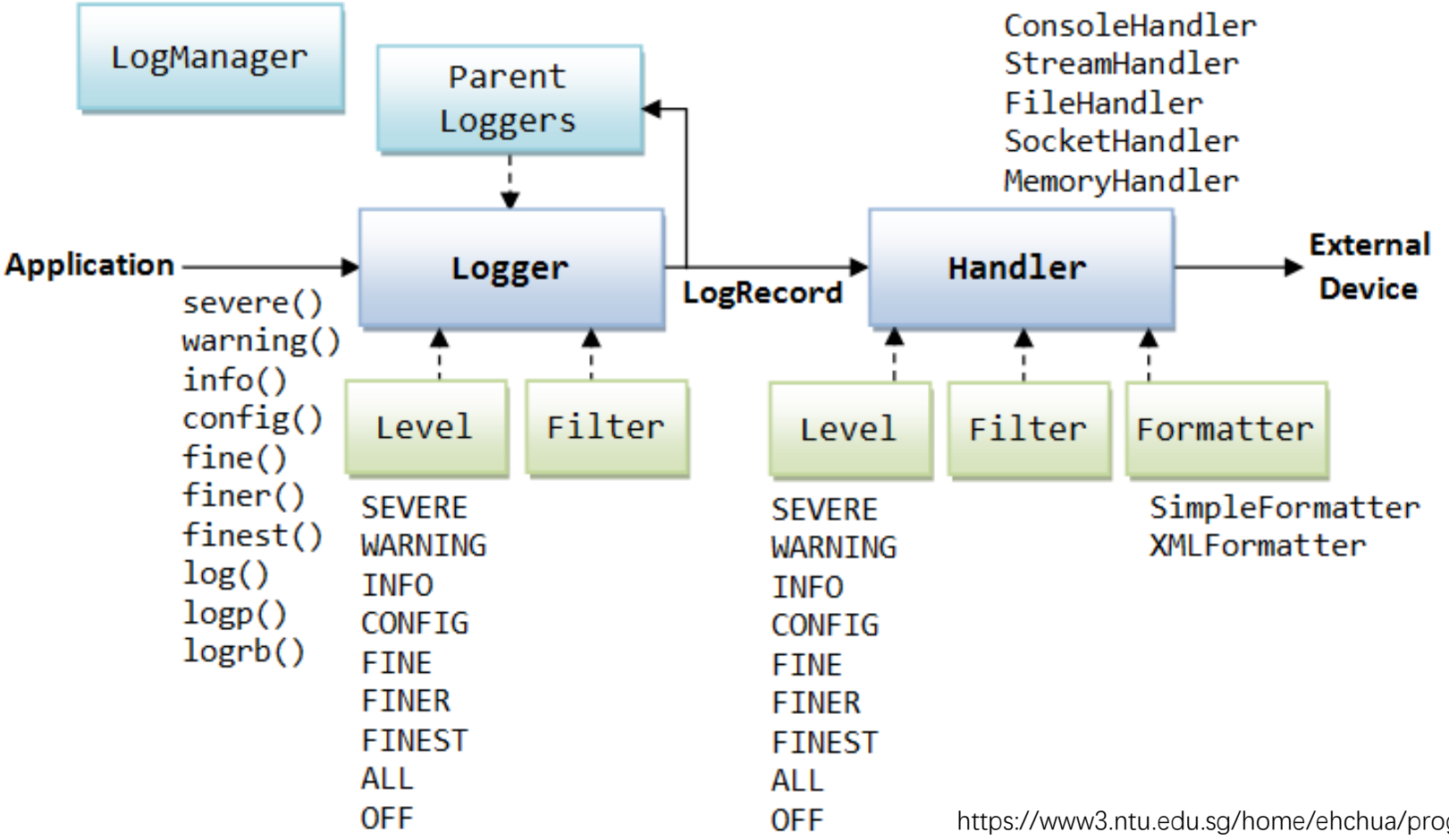

```java
import com.foo.Bar;

// Import log4j classes.
import org.apache.logging.log4j.Logger;
import org.apache.logging.log4j.LogManager;

public class MyApp {

    // Define a static logger variable so that it references the
    // Logger instance named "MyApp".
    private static final Logger logger = LogManager.getLogger(MyApp.class);

    public static void main(final String... args) {

        // Set up a simple configuration that logs on the console.

        logger.trace("Entering application.");
        Bar bar = new Bar();
        if (!bar.doIt()) {
            logger.error("Didn't do it.");
        }
        logger.trace("Exiting application.");
    }
}
```

https://logging.apache.org/log4j/2.x/manual/configuration.html

Apache Log4j

Java logging framework

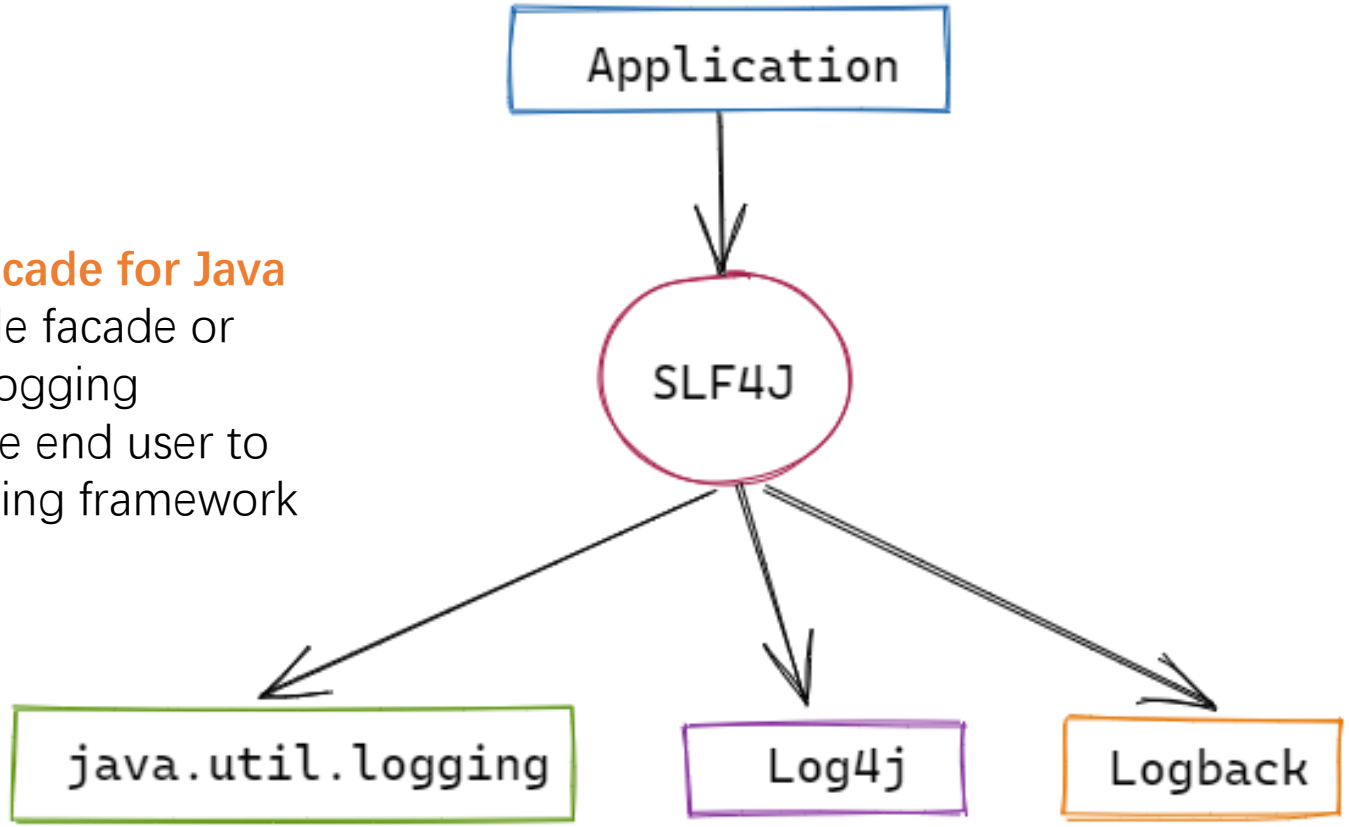
(`java.util.logging`, since JDK 1.4)



https://www3.ntu.edu.sg/home/ehchua/programming/java/JavaLogging.html

Use Logging in Java Applications

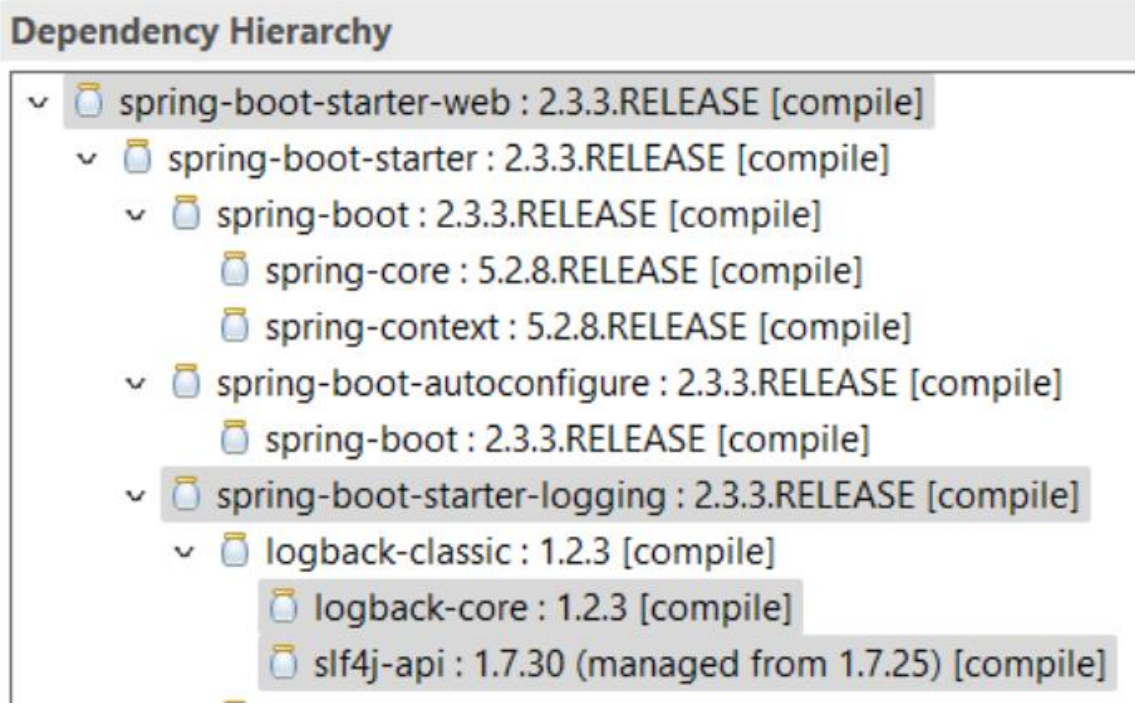
The **Simple Logging Facade for Java** (SLF4J) serves as a simple facade or abstraction for various logging frameworks, allowing the end user to plug in the desired logging framework at deployment time.



Logging in Spring Boot

- In Spring Boot, default logging uses Logback to log DEBUG messages into the Console.

- Most boot starters, such as `spring-boot-starter-web`, depends on `spring-boot-starter-logging`, which pulls in `logback` for us.



Default Logging in Spring Boot

- By default, when no default configuration file is found, `logback` will add a `ConsoleAppender` to the root logger and this will log all the messages in the Console.
- By default, the output is formatted using a `PatternLayoutEncoder`
- The default logging level of the Logger is preset to `INFO`, meaning that `TRACE` and `DEBUG` messages are not visible

Default Logging in Spring Boot

```
  .   ____          _            __ _ _
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( ( )\___ | '_ | '_| | '_ \/ _` | \ \ \ \
 \\/  ___)| |_)| | | | | || (_| |  ) ) ) )
  '  |____| .__|_| |_|_| |_\__, | / / / /
 =========|_|==============|___/=/_/_/_/
 :: Spring Boot ::                (v3.2.0)

2023-12-12T20:20:18.661+08:00  INFO 28164 --- [           main] c.e.s.SpringLoggingDemoApplication       : Starting SpringLoggin
2023-12-12T20:20:18.668+08:00  INFO 28164 --- [           main] c.e.s.SpringLoggingDemoApplication       : No active profile set
2023-12-12T20:20:19.454+08:00  INFO 28164 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat initialized wi
2023-12-12T20:20:19.474+08:00  INFO 28164 --- [           main] o.apache.catalina.core.StandardService   : Starting service [Tom
2023-12-12T20:20:19.475+08:00  INFO 28164 --- [           main] o.apache.catalina.core.StandardEngine    : Starting Servlet engi
2023-12-12T20:20:19.532+08:00  INFO 28164 --- [           main] o.a.c.c.C.[Tomcat].[localhost].[/]       : Initializing Spring e
2023-12-12T20:20:19.532+08:00  INFO 28164 --- [           main] w.s.c.ServletWebServerApplicationContext : Root WebApplicationCo
```

Default logging for Spring Boot DOES NOT count for the logging requirements in the final project!

Use Logging in Spring Boot

```
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import org.springframework.boot.SpringApplication;
import org.springframework.boot.autoconfigure.SpringBootApplication;

@SpringBootApplication
public class SpringLoggingDemoApplication {
    private static final Logger LOGGER= LoggerFactory.getLogger(SpringLoggingDemoApplication.class);

    public static void main(String[] args) {
        SpringApplication.run(SpringLoggingDemoApplication.class, args);

        LOGGER.info("Customized INFO log {}", 1);
        LOGGER.debug("Customized DEBUG log {}", 2);
        LOGGER.error("Customized ERROR log {}", 3);
        LOGGER.trace("Customized TRACE log {}", 4);
    }
}
```

Use Logging in Spring Boot

```
 \\/  ___)| |_)| | | | | || (_| |  ) ) ) )
  '  |____| .__|_| |_|_| |_\__, | / / / /
 =========|_|==============|___/=/_/_/_/
 :: Spring Boot ::                (v3.2.0)

2023-12-12T20:30:59.865+08:00  INFO 24732 --- [           main] c.e.s.SpringLoggingDemoApplication       : Starting SpringLoggingD
2023-12-12T20:30:59.867+08:00  INFO 24732 --- [           main] c.e.s.SpringLoggingDemoApplication       : No active profile set,
2023-12-12T20:31:00.679+08:00  INFO 24732 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat initialized with
2023-12-12T20:31:00.688+08:00  INFO 24732 --- [           main] o.apache.catalina.core.StandardService   : Starting service [Tomca
2023-12-12T20:31:00.688+08:00  INFO 24732 --- [           main] o.apache.catalina.core.StandardEngine    : Starting Servlet engine
2023-12-12T20:31:00.757+08:00  INFO 24732 --- [           main] o.a.c.c.C.[Tomcat].[localhost].[/]       : Initializing Spring emb
2023-12-12T20:31:00.757+08:00  INFO 24732 --- [           main] w.s.c.ServletWebServerApplicationContext : Root WebApplicationCont
2023-12-12T20:31:01.040+08:00  INFO 24732 --- [           main] o.s.b.w.embedded.tomcat.TomcatWebServer  : Tomcat started on port
2023-12-12T20:31:01.046+08:00  INFO 24732 --- [           main] c.e.s.SpringLoggingDemoApplication       : Started SpringLoggingDe
2023-12-12T20:31:01.048+08:00  INFO 24732 --- [           main] c.e.s.SpringLoggingDemoApplication       : Customized INFO log 1
2023-12-12T20:31:01.049+08:00 ERROR 24732 --- [           main] c.e.s.SpringLoggingDemoApplication       : Customized ERROR log 3
```

Next Lecture

- JVM