Scuola universitaria professionale della Svizzera italiana
Dipartimento tecnologie innovative

SUPSI

2D image editor

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STUDENTSUPSI

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CONTEXT AND MOTIVATION

ACADEMIC PROJECT

Academic software engineering project focusing on implementing software design patterns and testing best practices

ANALYZE REQUIREMENTS

Creation of a 2D image editor with support for applying multiple filters in a pipeline architecture

CREATE A 2D EDITOR

Development of an extensible application enabling filter chaining, comprehensive testing coverage, and appropriate design pattern usage

PROBLEM

Create a modular 2D image editor capable of loading different image formats (PBM, PPM, PGM) and applying a customizable pipeline of filters. The application must support:

- Loading and saving images in PNM formats
- Dynamic filter pipeline management
- Cross-format image conversion
- Preferences management
- Localization in multiple languages

STATE OF THE ART

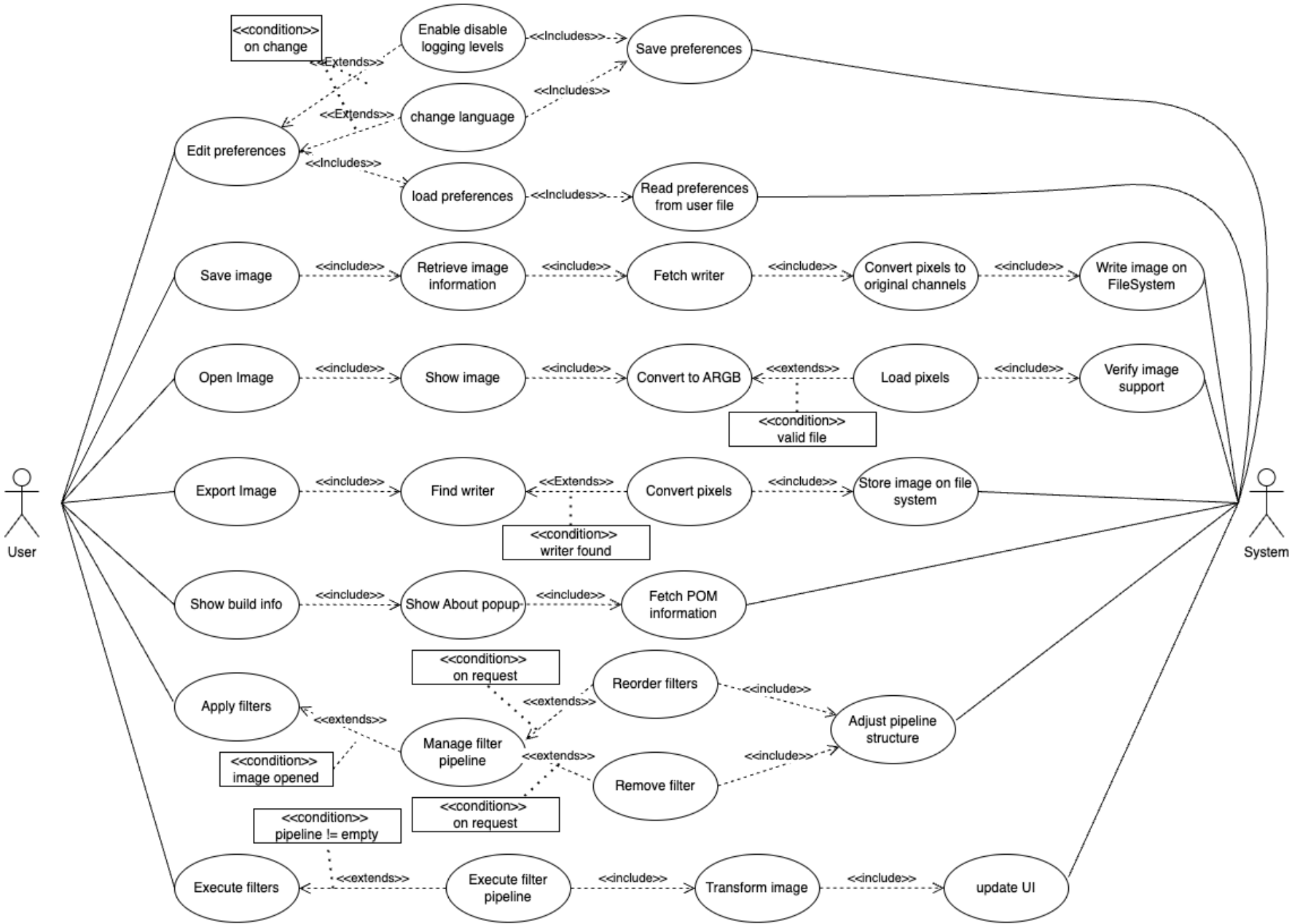
ADOBE PHOTOSHOP

LUMINAR NEO

PHOTO DIRECTOR

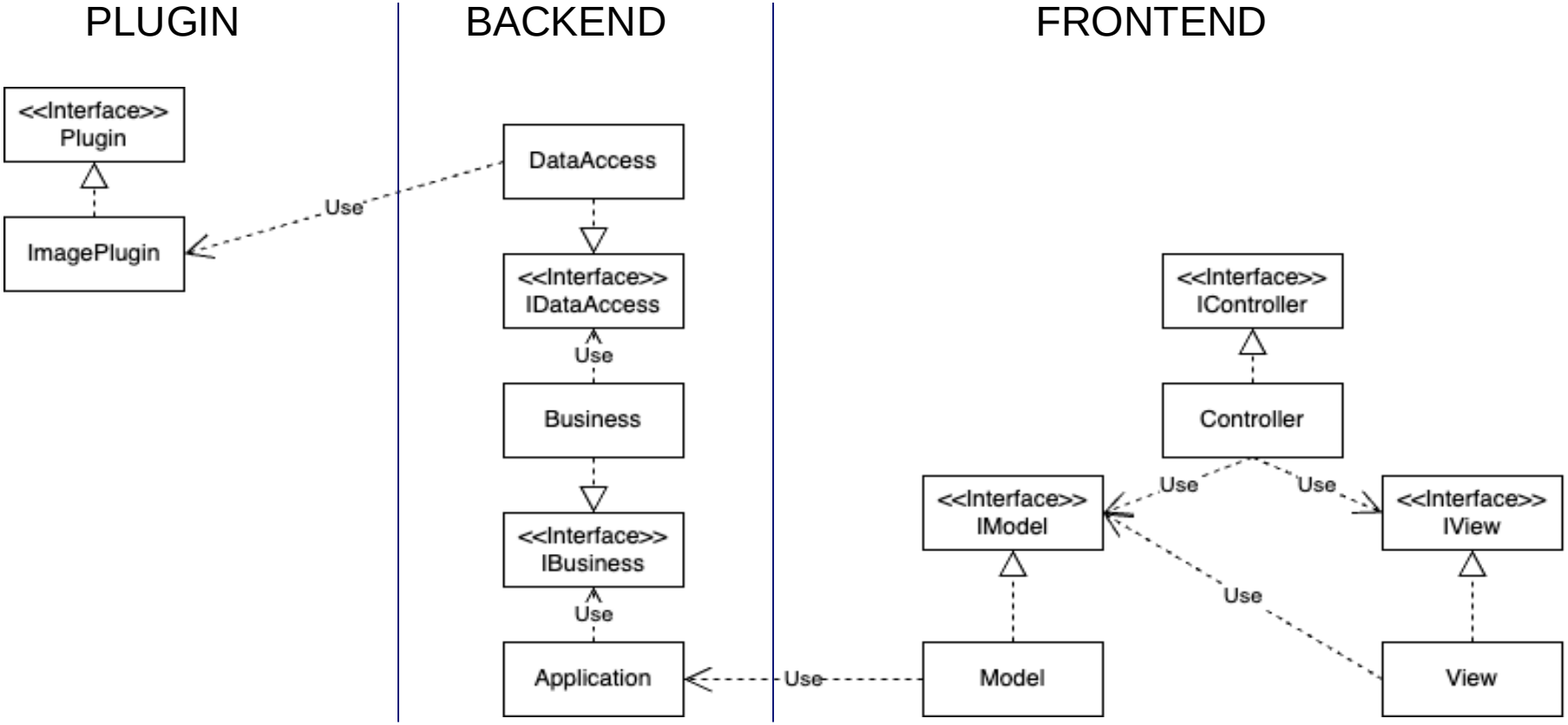
CAPTURE ONE PRO

USE CASE (1 of 1)



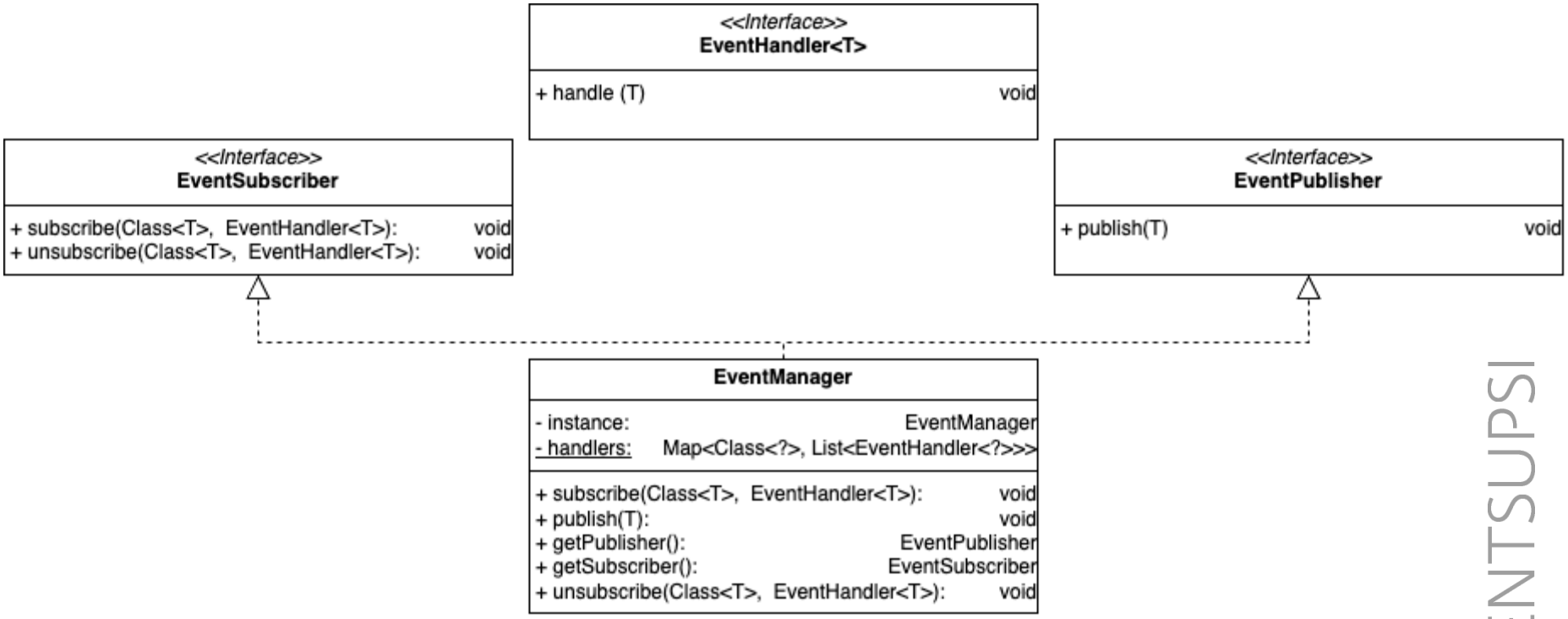
APPROACH (1 of 15)

Architecture



APPROACH (2 of 15)

Patterns - Observer



APPROACH (3 of 15)

Patterns - Observer

```
public sealed interface FilterEvent {
    record FilterAddRequested(String filterName) implements FilterEvent {}
    record FilterRemoveRequested(int index) implements FilterEvent {}
    record FilterMoveRequested(int fromIndex, int toIndex) implements FilterEvent {}
    record FilterExecutionRequested() implements FilterEvent {}
}
```

Controller:

```
EventSubscriber subscriber = EventManager.getSubscriber();

subscriber.subscribe(FilterEvent.FilterAddRequested.class, this::onFilterAdded);
```

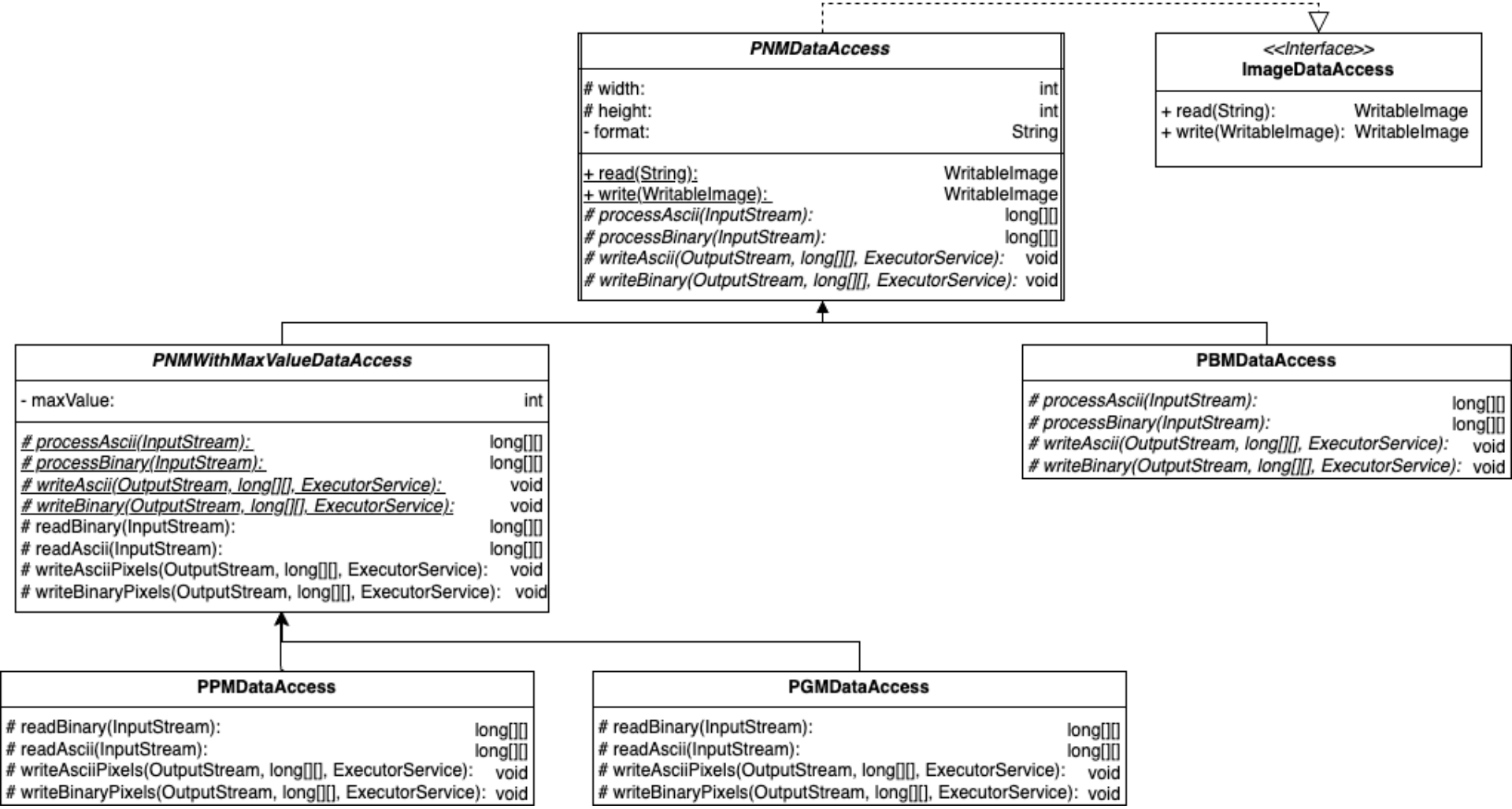
View:

```
EventPublisher publisher = EventManager.getPublisher();

publisher.publish(new FilterEvent.FilterAddRequested(filterKey))
```

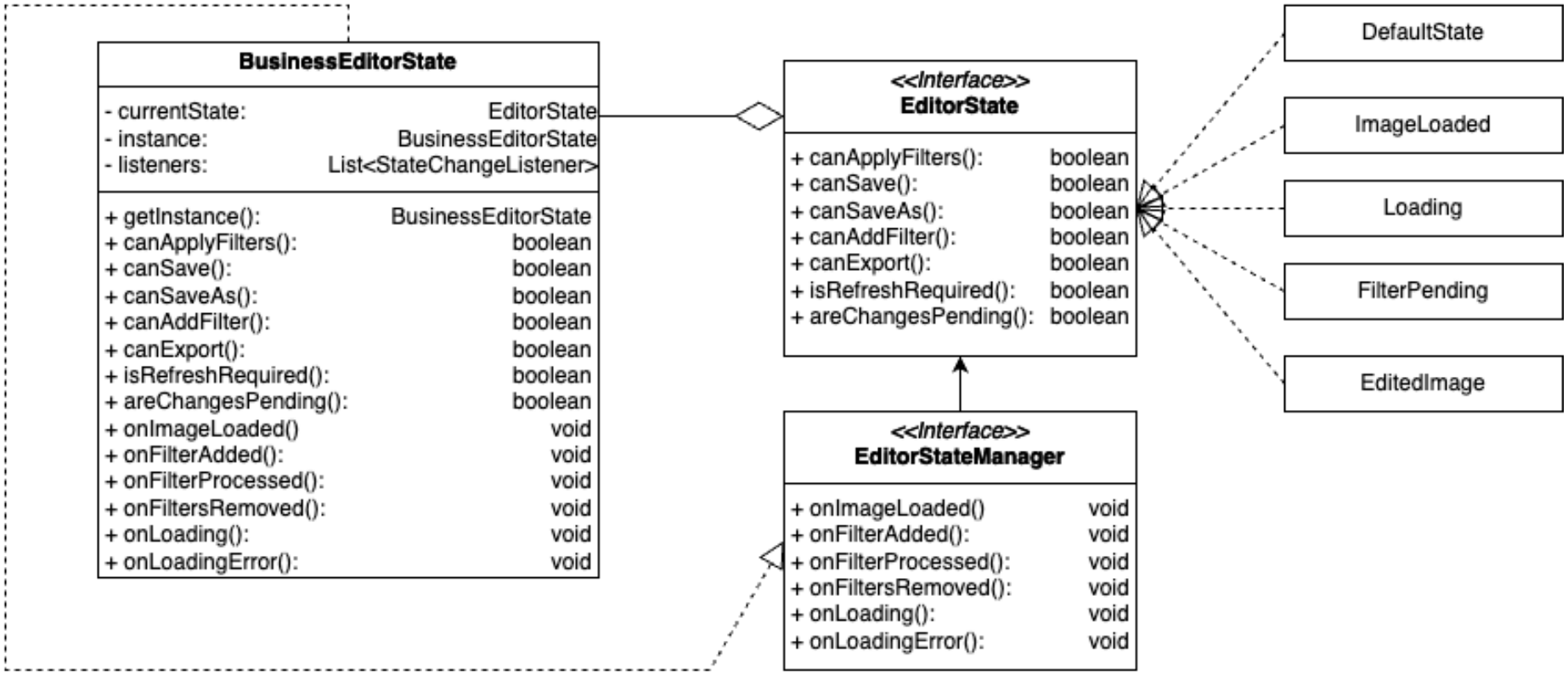
APPROACH (4 of 15)

Patterns - Template



APPROACH (5 of 15)

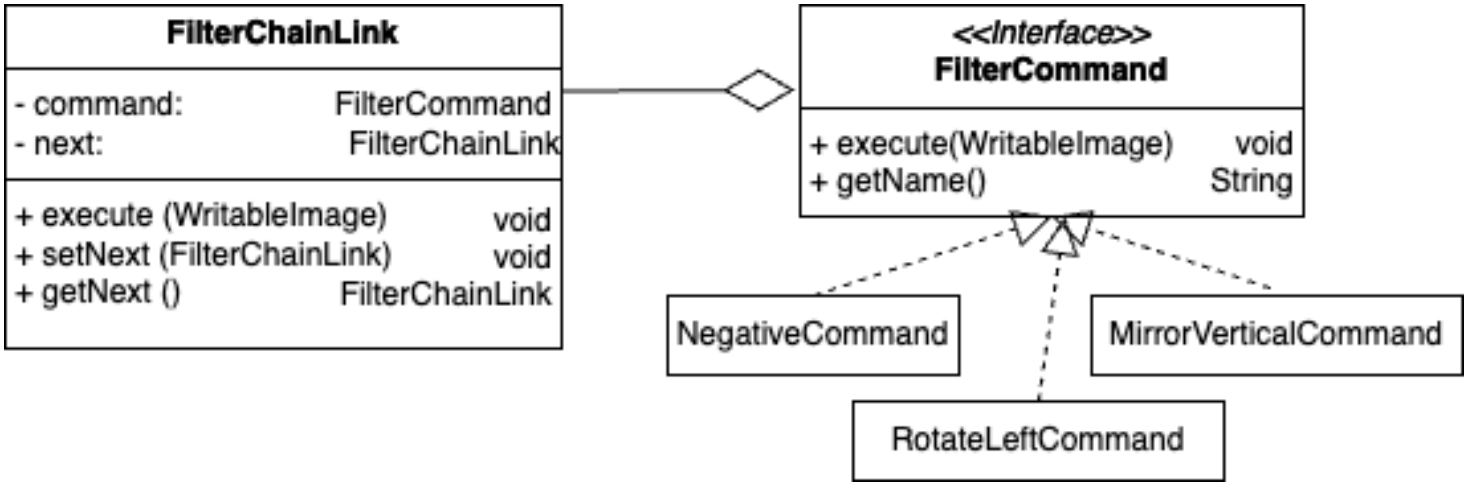
Patterns - State



APPROACH (6 of 15)

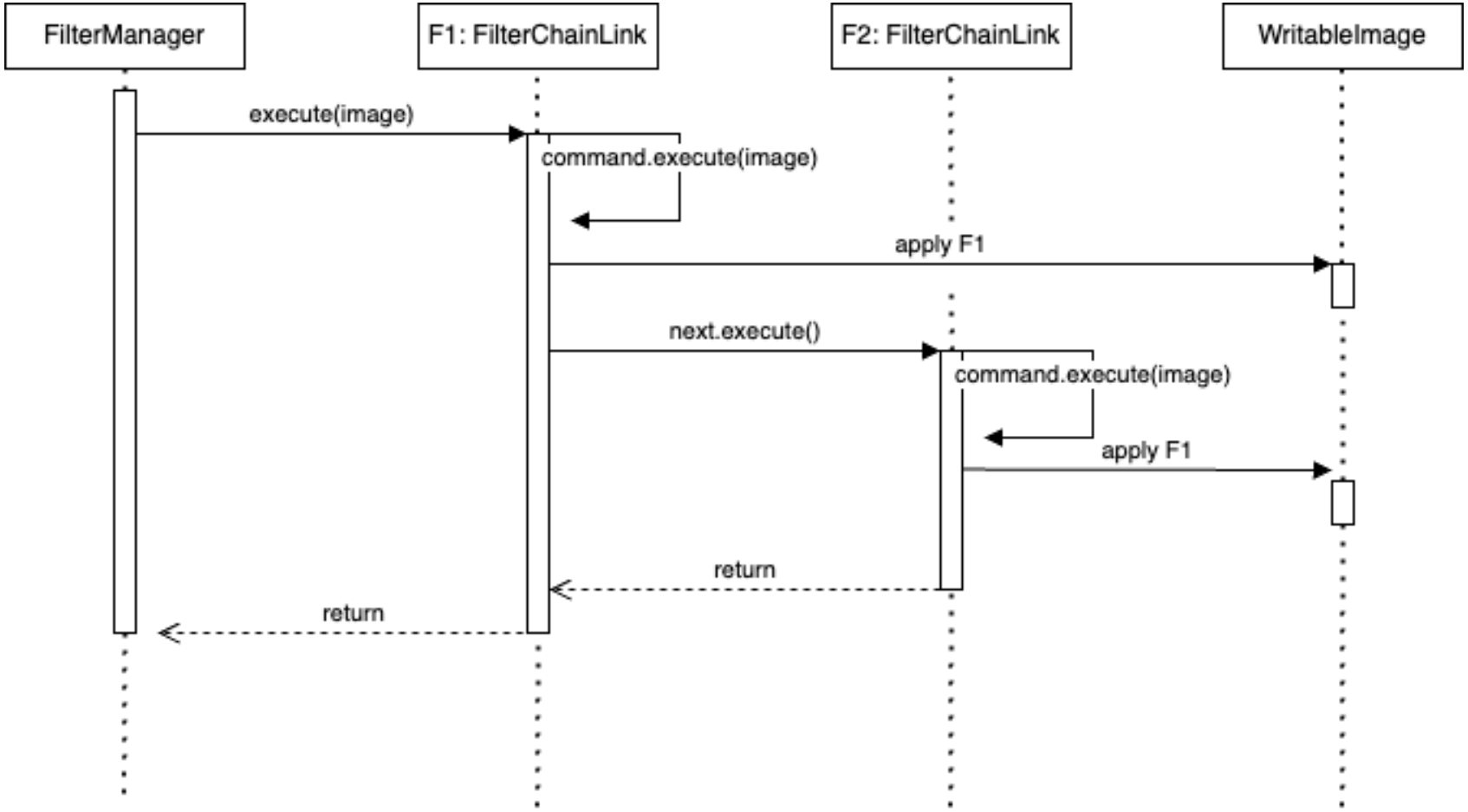
Patterns – Chain of responsability

- Order matters
- If a command fails, others should not be executed
- Every component processes the image.
- It provides support for single filter execution
- Commands are wrapped, in this way no component ‘knows’ other components on the same layer
- Commands are stateless, so they can be cached and used multiple times, even in the same pipeline, without side effects or circular dependencies.



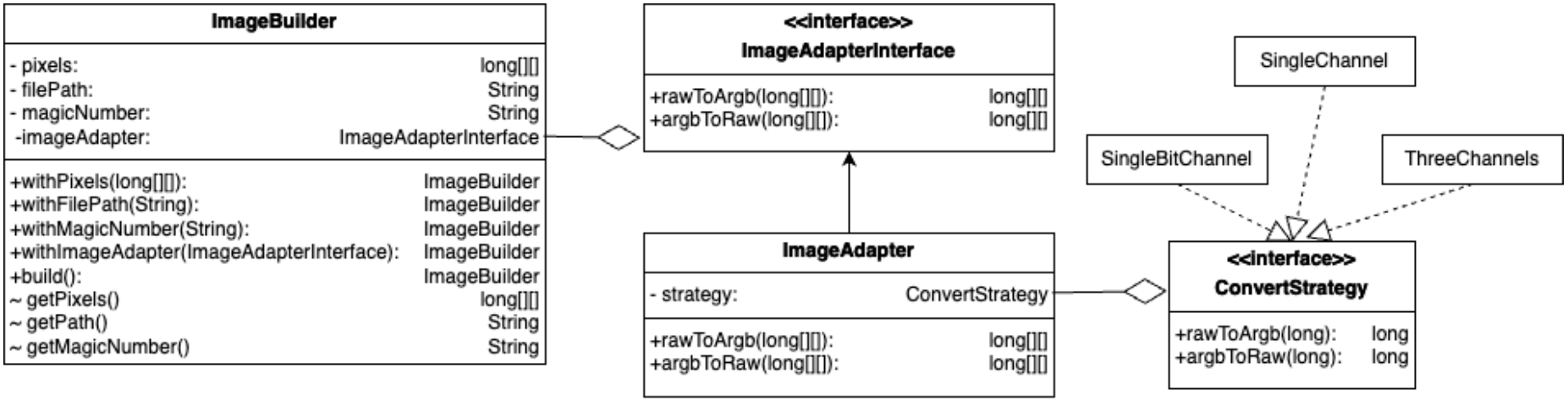
APPROACH (7 of 15)

Patterns – Chain of responsability



APPROACH (8 of 15)

Patterns - Strategy



APPROACH (9 of 15)

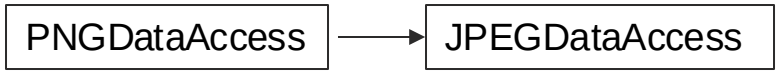
Patterns - Strategy

```java
@Override
public long ArgbToOriginal(long pixel) {
    int r = (int) ((pixel >> 16) & 0xFF);
    int g = (int) ((pixel >> 8) & 0xFF);
    int b = (int) (pixel & 0xFF);

    if (r != g || g != b) {
        return (long) (((0.299 * r + 0.587 * g + 0.114 * b) / 255.0) * maxValue);
    } else {
        return (long) ((b / 255.0) * maxValue);
    }
}
```

APPROACH (10 of 15)

Patterns – Dependency Injection



Chain of Responsibility

- Performance overhead due to runtime chain traversal
- High coupling: components require knowledge of other components at same level
- Poor extensibility: adding new components requires modifying existing code
- Error propagation: failures in one component can cascade through the chain
- Complex debugging of chain execution flow

Chain of Responsibility with Configuration

- Violates Java's 'convention over configuration' principle
- Runtime overhead for configuration parsing
- Additional complexity from reflection-based validation
- Same coupling and separation of concerns issues as basic chain
- Configuration maintenance becomes an extra burden

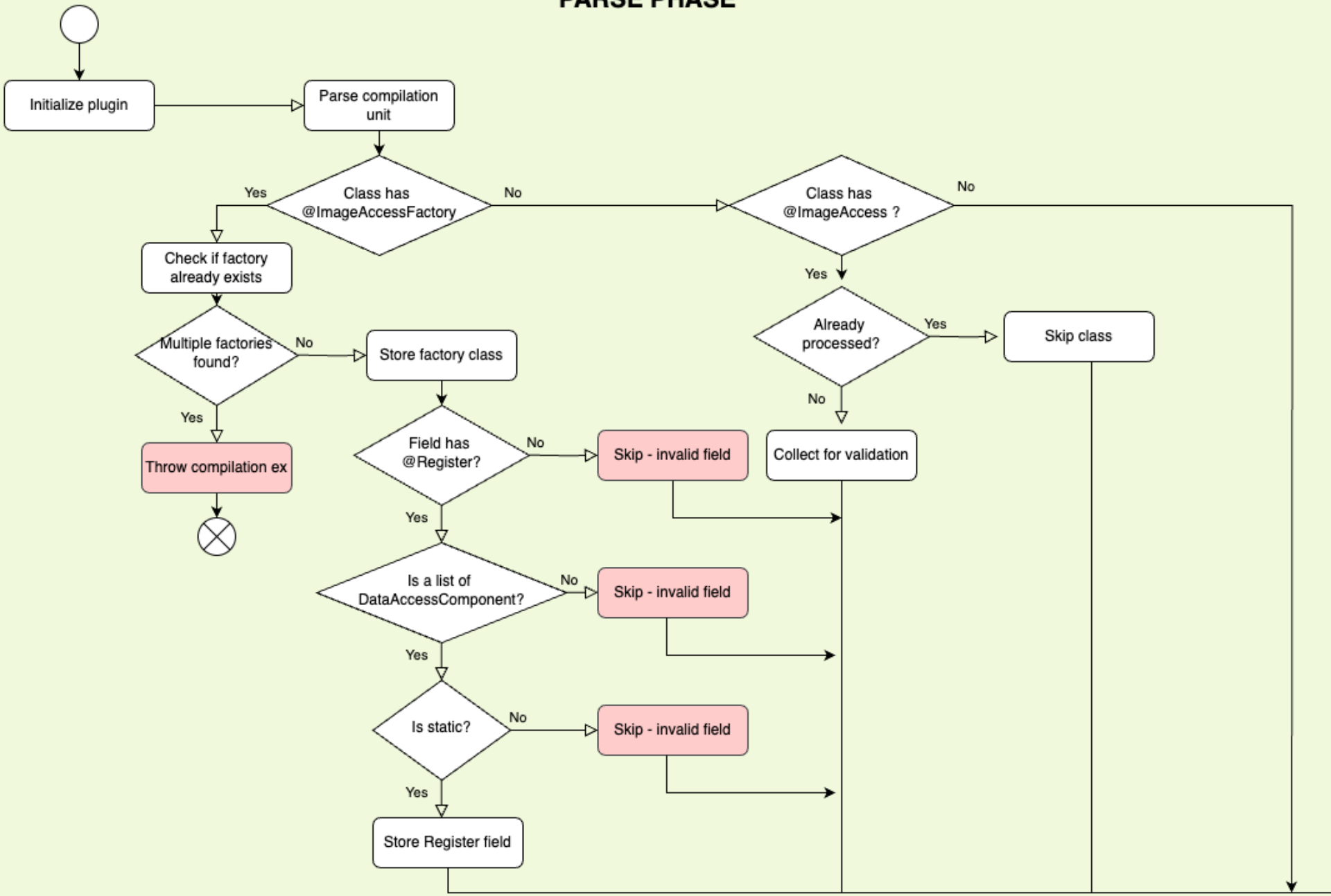
APPROACH (11 of 15)

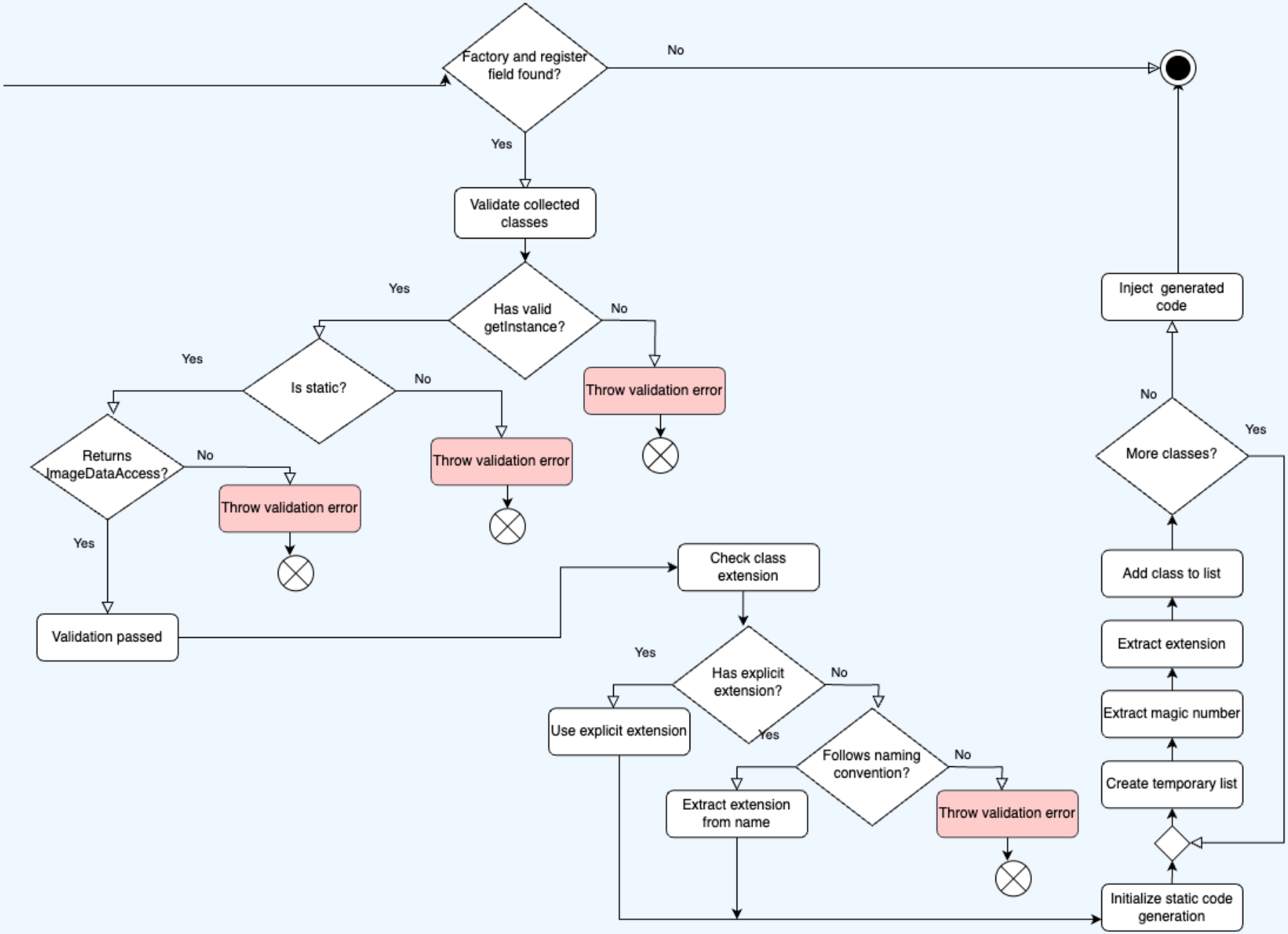
Patterns – Dependency Injection

Pure Reflection Approach
- More flexible and decoupled design
- Significant runtime performance overhead
- Defers critical validation to runtime
- Potential runtime failures from incorrect implementations (e.g., malformed singletons)
- Complex error handling and recovery

Compiler plugin (Selected Solution) → Native javac plugin
- Compile-time validation and code generation
- No runtime overhead
- Early detection of implementation errors
- Better separation of concerns
- Follows Java conventions for extensibility
- Simplified maintenance and debugging
- Flawless extensibility

PARSE PHASE


Initialize plugin
Parse compilation unit
Class has @ImageAccessFactory
Yes
No
Check if factory already exists
Multiple factories found?
No
Yes
Throw compilation ex
Store factory class
Field has @Register?
No
Skip - invalid field
Yes
Is a list of DataAccessComponent?
No
Skip - invalid field
Yes
Is static?
No
Skip - invalid field
Yes
Store Register field
Class has @ImageAccess ?
No
Yes
Already processed?
Yes
Skip class
No
Collect for validation


Factory and register field found?
No
Yes
Validate collected classes
Has valid getInstance?
Yes
No
Throw validation error
Is static?
Yes
No
Throw validation error
Returns ImageDataAccess?
No
Throw validation error
Yes
Validation passed
Check class extension
Has explicit extension?
Yes
No
Use explicit extension
Follows naming convention?
Yes
No
Extract extension from name
Throw validation error
Initialize static code generation
Create temporary list
Extract magic number
Extract extension
Add class to list
More classes?
No
Yes
Inject generated code

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APPROACH (14 of 15)

Patterns – Dependency Injection

```java
@ImageAccessFactory
public class DataAccessFactory {

    /** {@link List} of registered data access components. */
    @Register  4 usages
    private static List<DataAccessComponent> dataAccessComponents;
```

Decompiled .class file, bytecode version: 61.0 (Java 17)

```java
22  public class DataAccessFactory {  no usages
146     static {
147         List<DataAccessComponent> tempList = new ArrayList();
148         DataAccessComponent component0 = new DataAccessComponent();
149         component0.magicNumber = new String[]{"P3", "P6"};
150         component0.extension = "ppm";
151         component0.clazz = PPMDataAccess.class;
152         tempList.add(component0);
153         DataAccessComponent component1 = new DataAccessComponent();
154         component1.magicNumber = new String[]{"P1", "P4"};
155         component1.extension = "pbm";
156         component1.clazz = PBMDataAccess.class;
157         tempList.add(component1);
158         DataAccessComponent component2 = new DataAccessComponent();
159         component2.magicNumber = new String[]{"P2", "P5"};
160         component2.extension = "pgm";
161         component2.clazz = PGMDataAccess.class;
162         tempList.add(component2);
163         dataAccessComponents = tempList;
164     }
165 }
166
```

APPROACH (15 of 15)

Optional – Exceptions – Modules

Optional vs Null:
- Using Optional makes it explicit that a value might not be present
- Forces conscious handling of null cases through methods like orElse/orElseThrow
- Improves code readability and maintainability by reducing NullPointerExceptions

Exception Handling:
- Exceptions propagated from the backend are caught in the frontend
- Frontend translates them into user-friendly messages through ErrorController

Java Modules:
- Clear separation between backend and frontend through module-info.java
- Translation bundles are encapsulated in their respective modules (better organization)
- Precise control over dependencies and package access
- Strong encapsulation: only intentionally exposed APIs are accessible
- Better architectural design

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TESTS (1 of 2)

Coverage

	CLASSES	COV	LINES	COV	METHODS	COV	BRANCHES	COV
BACKEND	37	100%	4.425	100%	277	100%	426	100%
FRONTEND	45	100%	3.626	100%	266	100%	168	100%

	TESTS
BACKEND	326
FRONTEND	166
PLUGIN	20

512 tests

TESTS (1 of 2)

Strategies

JUNIT 5
- Test framework

TESTFX
- End-to-end tests

MOCKITO
- Mock
- Spy
- Static mock
- Mocked construction

JAVAASSIST
- Runtime dynamic bytecode generation

JAVA TOOLS
- Runtime code compilation

JUNIT Standalone
- Plugin testing

JACOCO
- Test coverage

ADDITIONAL DOCUMENTATION (1 of 1)

TEST REPORTS

CODE DOCUMENTATION

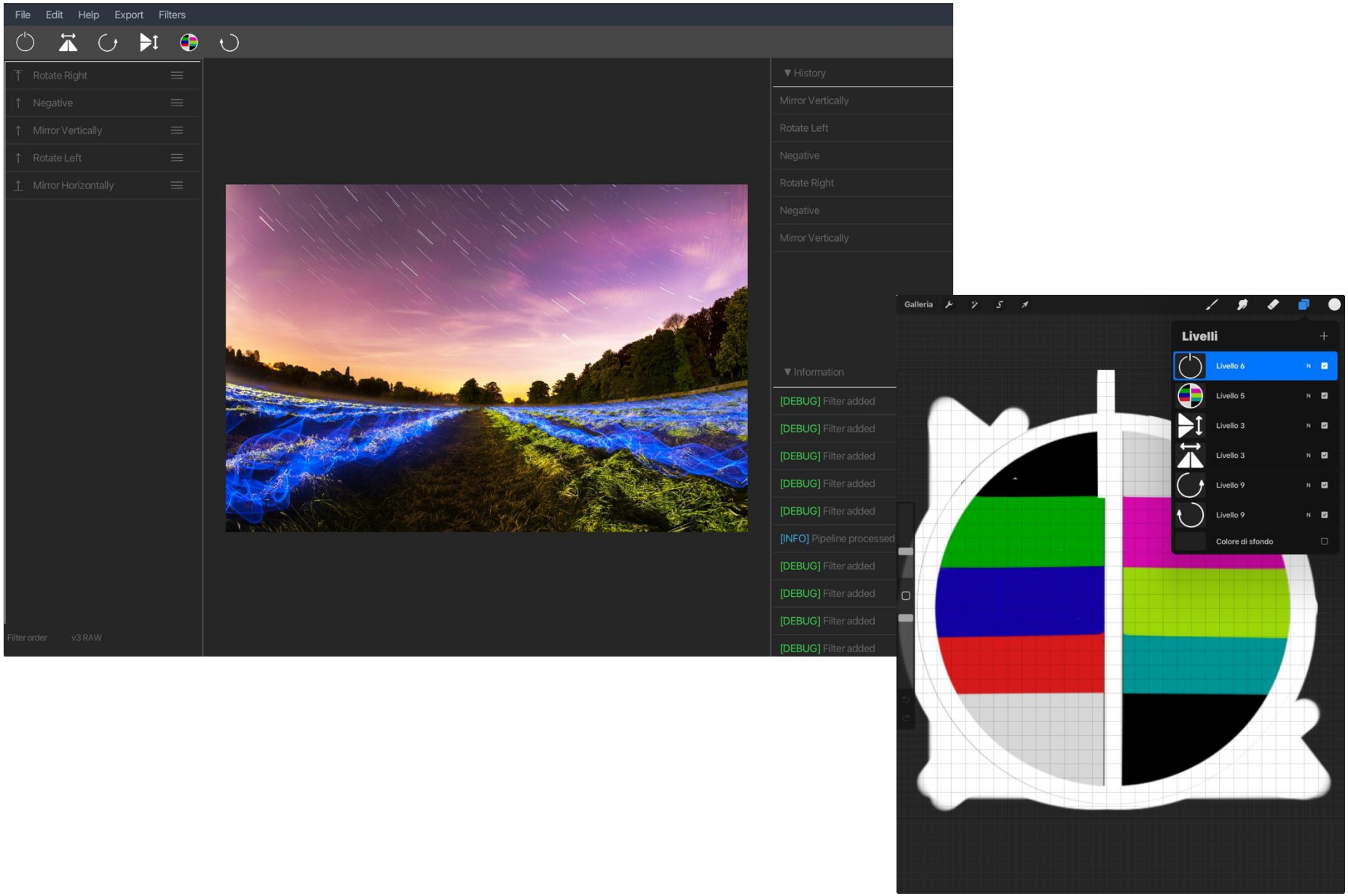
MAINTEINANCE GUIDE

BUILD SCRIPTS

DIAGRAMS

README

USER INTERFACE (1 of 1)



DEMO

CONCLUSIONS