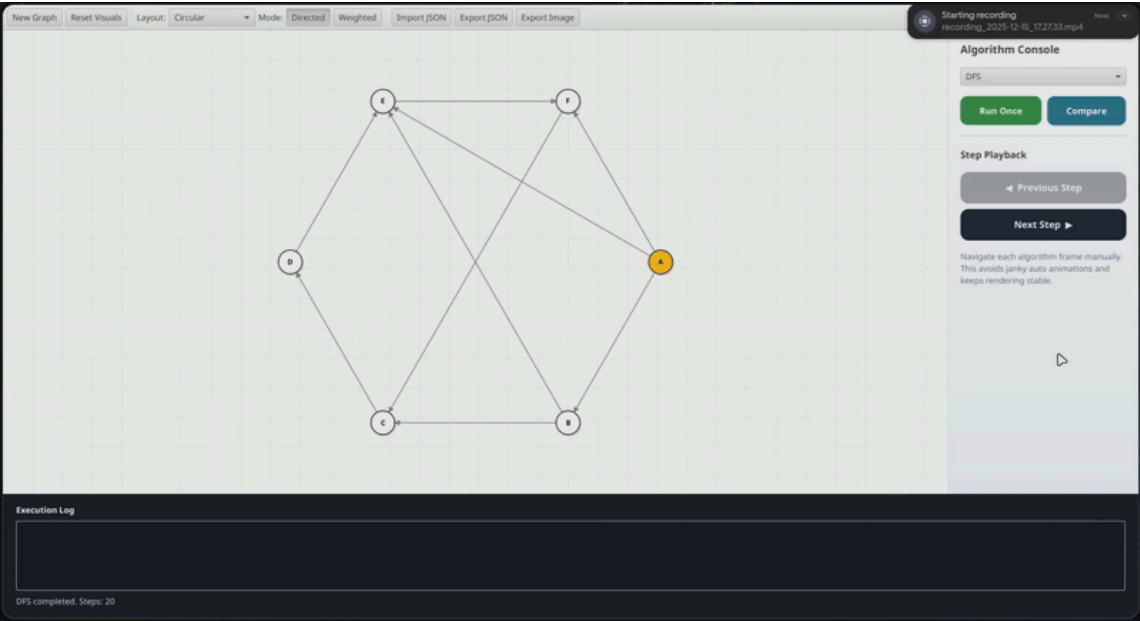


# GraphVizFX Code Review Report

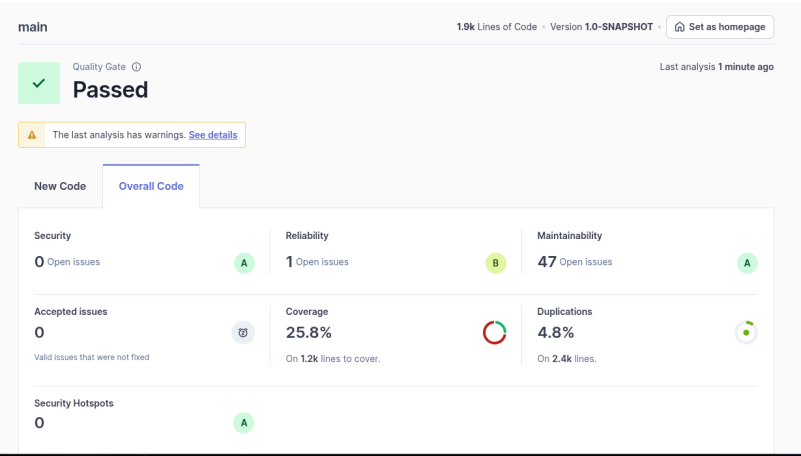
## 1. Executive Summary



- JavaFX-based graph visualizer with interactive canvas, multiple layouts, and animated algorithm traces; packages are cleanly separated and interfaces enable extension.
- Strengths: clear MVC-ish layering, reusable `GraphAlgorithm` / `LayoutAlgorithm` strategies, and a meaningful JUnit suite that exercises algorithms, layouts, and JSON I/O.
- Critical weaknesses: weak domain encapsulation (mutable collections, identity-only edge checks), regex-driven parsers that risk data loss/corruption, and algorithm efficiency/validation gaps (MST correctness, neighbor scanning, shallow visual-state copying).

## 2. Code Quality Audit

### 2.1 Static Analysis (SonarQube)



- Coverage at **25.8%** directly reinforces the Executive Summary's critical weakness around insufficient testing.
- Despite an **A** in Maintainability, the **B** in Reliability signals at least one non-trivial bug that should be triaged and fixed before release.

### 3. Architecture & Design Patterns

- **MVC assessment:**
  - `app/GraphVizFX` (View bootstrap) wires `GraphController` (Controller) and `GraphModel` (Model) with `GraphCanvas` (View). Separation is decent for algorithm execution and layout, but the View performs model mutation (node/edge creation/deletion) directly via controller without validation in the model itself, weakening encapsulation.
  - `GraphCanvas` mixes rendering and input handling, causing UI logic to leak into the View layer; `GraphController` is thin and delegates almost everything to `GraphModel` with no domain guards.
- **Patterns in use:**
  - **Strategy:** `GraphAlgorithm` and `LayoutAlgorithm` interfaces with concrete BFS/DFS/Dijkstra/A\*/Prim/Kruskal and Grid/Circular/Force-Directed implementations. Good extensibility, but algorithms share neighbor-scanning inefficiencies and lack shared adjacency helpers.
  - **Factory-ish:** `AlgorithmEngine.createAlgorithm` acts as a simple factory switch; no error recovery or registration mechanism, so open/closed is limited.
  - **Singleton:** none. No global state—good.
  - **Observer/Event:** not used; UI polling and redraws are manual.
- **Interface vs concrete use:** Interfaces are present but concrete classes are manipulated directly (e.g., `new GraphController()`), and `GraphModel` exposes mutability, so substitution is limited. No DI; testing stubs would require refactoring.

### 4. Algorithmic Analysis

- **Shared inefficiency:** All algorithms iterate `graph.getEdges()` to find neighbors each step. Time blows up to  $O(VE)$  even for sparse graphs; space remains minimal but repeated map mutation/copying in `VisualState` can be costly.
- **Complexities (current implementation):**
  - **BFS ( `BFSAlgorithm` ):** Time  $O(V \cdot E)$  due to global edge scans; Space  $O(V+E)$  for queue, visited, and color maps.
  - **DFS ( `DFSAlgorithm` ):** Time  $O(V \cdot E)$ ; Space  $O(V+E)$  for stack, visited, and colors.
  - **Dijkstra ( `DijkstraAlgorithm` ):** Time  $O(V \cdot E + V \log V)$  (PQ plus edge scans); Space  $O(V+E)$  for distances, PQ, settled, colors.
  - **A ( `AStarAlgorithm` )<sup>\*</sup>:** Time  $O(V \cdot E + V \log V)$ ; Space  $O(V+E)$  for g-scores, parents, open/closed, colors.
  - **Prim ( `PrimAlgorithm` ):** Time  $O(E \log E + V \cdot E)$  because of re-adding adjacent edges and global scans; Space  $O(E)$  for PQ plus color maps.
  - **Kruskal ( `KruskalAlgorithm` ):** Time  $O(E \log E + \alpha(V))$  for sorting and union-find, but still iterates all edges; Space  $O(E+V)$  for sorted edges and parent map.
- **Critique:** Building adjacency lists once per run would reduce BFS/DFS to  $O(V+E)$ , Dijkstra/A\* to  $O((V+E) \log V)$ , and clean up edge-color mutation. MSTs should stop after  $|V| - 1$  edges and reject directed/disconnected graphs.

### 5. Code Quality & SOLID

- **Single Responsibility:**
  - `GraphCanvas` handles rendering, hit-testing, node/edge creation/deletion, and context menus—multiple responsibilities.
  - `GraphVizFX` combines UI composition, state management, status/log control, and algorithm orchestration.
- **Open/Closed:**
  - Algorithms/layouts can be added via new classes, but `AlgorithmEngine` switch violates OCP; adding types requires edits there.
  - Parsers ( `JSONImporter` , `OSMImporter` ) are rigid regex implementations; swapping parsers requires rewriting classes.
- **Liskov Substitution:** Interfaces are simple and respected; however, `GraphModel` 's exposed lists allow invariants to be broken, so substitutable implementations would need tighter contracts.
- **God classes / coupling:** `GraphCanvas` is UI-heavy and stateful; `GraphVizFX` is a large orchestrator. Model, controller, and view coupling is high because the model exposes internals and the view mutates them directly.
- **Standards / hygiene:** Naming matches Java conventions. Magic numbers abound (canvas padding, radii, colors, force-directed constants). Minimal Javadoc on methods. No nullability annotations.

## 6. Robustness & Security

- **JSONImporter:**
  - Regex-based; clears graph before validation; admits duplicates and malformed numeric fields; no size limits; errors can leave users with emptied graphs.
  - No UTF-8 enforcement or streaming—large files could be memory-heavy.
- **OSMImporter:**
  - Regex on XML-like data; silently skips invalid coordinates; no schema validation; accepts duplicate node IDs; lacks safeguards against huge files.
- **GraphModel encapsulation:**
  - `getNodes()` / `getEdges()` return mutable lists; `hasEdge` uses object identity and direction only, so undirected duplicates slip in; no invariants on unique IDs or self-loops.
- **Error handling:** Broad `catch (Exception e)` in `GraphVizFX` hides root causes; IO errors lack logging.

## 7. JavaFX Specifics

- **UI thread safety:** All UI interactions occur on FX thread (`Application.start()`). Long-running layout/algorithms execute synchronously and can freeze UI; no background tasks are used.
- **Rendering efficiency:** `GraphCanvas.draw()` redraws entire scene every call and recomputes grid/background each time. No dirty-region tracking or cached backgrounds. Edge hit-testing recomputes distances for all edges on each click.
- **Input UX:** Right-click deletion has no confirmation/undo; silent failures on invalid edge creation. Weight editing swallows `NumberFormatException` silently.

## 8. Testing

- **Coverage:** JUnit 5 tests cover BFS/DFS/Dijkstra behaviors, layout bounds, model edge/clear, JSON round-trip, and empty-file failure. Missing coverage for A\*, Prim, Kruskal, OSM import, directed graphs, negative weights, disconnected MSTs, and concurrency/UI freezing.
- **Quality:** Tests are readable and deterministic using `TestGraphFactory`. Edge cases for null start nodes are checked; disconnected nodes in Dijkstra are verified. MST and A\* paths are untested;

importers lack malformed/large input tests.

## 9. Detailed Issue Log

Severity	File/Method	Description	Suggested Fix
High	<code>io/JSONImporter.importGraph</code>	Regex parsing, clears graph upfront, no uniqueness/schema validation; malformed JSON can wipe state or admit duplicates.	Use Jackson/Gson, validate into a temp model, enforce unique IDs, and swap on success. Add max size guard.
High	<code>model/GraphModel</code>	Mutable list exposure; <code>hasEdge</code> identity-only; duplicates and dangling edges possible; no self-loop or direction checks.	Encapsulate add/remove, return unmodifiable views, make <code>hasEdge</code> symmetric for undirected graphs, and enforce IDs/loops centrally.
Medium	<code>algorithms/* neighbor scans</code>	BFS/DFS/Dijkstra/A*/Prim/Kruskal scan all edges per step ( $O(VE)$ ); <code>VisualState</code> maps mutate across steps.	Precompute adjacency maps and emit immutable snapshots per step.
Medium	<code>PrimAlgorithm / KruskalAlgorithm</code>	No validation for directed/disconnected graphs; may emit partial MSTs.	Guard directed graphs, stop after `
Low	<code>app/GraphVizFX error handling</code>	Broad catch ( <code>Exception e</code> ) hides causes; no logging.	Catch specific exceptions, log stack traces, and surface actionable messages.
Low	<code>io/OSMImporter</code>	Regex on XML; skips invalid coords silently; no duplicate detection or size limits.	Use XML/OSM parser, validate refs, enforce limits, and add tests.
Low	<code>view/GraphCanvas UX</code>	Destructive actions lack confirmation/undo; silent ignores on invalid edges; duplicate IDs allowed.	Validate in model/controller, provide feedback, and add undo/confirm flows.

## 10. Actionable Recommendations (with snippets)

- Encapsulate `GraphModel` and fix edge checks:

```
public final class GraphModel {
    private final Map<String, GNode> nodes = new HashMap<>();
    private final Set<GEdge> edges = new HashSet<>();

    public Collection<GNode> getNodes() { return
Collections.unmodifiableCollection(nodes.values()); }
    public Collection<GEdge> getEdges() { return
Collections.unmodifiableCollection(edges); }

    public void addNode(GNode n) {
        if (nodes.containsKey(n.getId())) throw new
IllegalArgumentException("Duplicate node id " + n.getId());
        nodes.put(n.getId(), n);
    }

    public void addEdge(GNode u, GNode v, int w, boolean directed) {
        if (u == v) throw new IllegalArgumentException("Self-loops not
allowed");
        GEdge e = new GEdge(u, v, w);
        if (!directed && edges.stream().anyMatch(x -> x.connects(u, v))) {
            throw new IllegalArgumentException("Duplicate undirected
edge");
        }
        edges.add(e);
    }
}
```

- Adjacency map for algorithms (reduces to  $O(V+E)$ ):

```
private Map<GNode, List<GEdge>> buildAdj(GraphModel g) {
    Map<GNode, List<GEdge>> adj = new HashMap<>();
    for (GEdge e : g.getEdges()) {
        adj.computeIfAbsent(e.getSource(), k -> new ArrayList<>()).add(e);
        if (!g.isDirected()) adj.computeIfAbsent(e.getTarget(), k -> new
ArrayList<>()).add(e);
    }
    return adj;
}

for (GEdge edge : adj.getOrDefault(current, List.of())) {
    GNode neighbor = edge.other(current);
    // relax / visit
}
```

- Immutable `VisualState` snapshots to avoid cross-step mutation:

```

public VisualState snapshot() {
    return new VisualState(
        Map.copyOf(nodeColors),
        Map.copyOf(edgeColors),
        Map.copyOf(distances),
        logLine
    );
}

```

- **Safe JSON import using Jackson:**

```

record EdgeDto(String from, String to, int weight) {}
record GraphDto(boolean directed, boolean weighted, List<GNodeDto> nodes,
List<EdgeDto> edges) {}

public static void importGraph(GraphModel graph, File file) throws IOException {
    GraphDto dto = new ObjectMapper().readValue(file, GraphDto.class);
    GraphModel tmp = new GraphModel();
    tmp.setDirected(dto.directed());
    tmp.setWeighted(dto.weighted());
    for (GNodeDto n : dto.nodes()) tmp.addNode(new GNode(n.id(), n.x(), n.y()));
    for (EdgeDto e : dto.edges()) tmp.addEdge(tmp.getNode(e.from()),
tmp.getNode(e.to()), e.weight(), tmp.isDirected());
    graph.replaceWith(tmp); // atomic swap
}

```

- **Background execution for UI responsiveness:** wrap algorithm/layout runs in `Task<List<VisualState>>` and update UI via `Platform.runLater` to avoid freezing the FX thread.

## 11. Grading

Estimated score: **86/100** — solid structure and partial coverage, but needs model encapsulation, parser hardening, performance improvements, and MST validation to reach production robustness.