mdexplore Render Paths

This document is the render/caching map for `mdexplore`. It complements `UML.md` by going deep on the render forks and cache ownership.

Use this file before changing Mermaid, PlantUML, preview caching, or PDF export.

0. One-Page Triage Card

Use this as the fast incident-response path before going deep.

Quick Procedure

1. Reproduce on one file with Mermaid diagrams.
2. Run the 4-case matrix in order:
   - JS GUI
   - JS PDF
   - Rust GUI
   - Rust PDF
3. Classify failure scope:
   - only GUI,
   - only PDF,
   - only Rust,
   - only JS,
   - all branches.
4. Jump directly to the matching code waypoints in section `10.3`.
5. Verify fix with both:
   - one small-diagram file,
   - one large multi-diagram file.

Command Checklist (Copy/Paste)

Use these commands from the project root (`/home/npepin/Projects/mdexplore`).

```
# 1) Launch with JS backend (baseline)
./mdexplore.sh --mermaid-backend js test
```

```
# 2) Launch with Rust backend (target branch)
./mdexplore.sh --mermaid-backend rust test
```

```
# 3) Force explicit Rust binary if needed
MDEXPLORE_MERMAID_RS_BIN=/home/npepin/.cargo/bin/mmdr \
  ./mdexplore.sh --mermaid-backend rust test
```

```
# 4) Open canonical small-diagram file during test run
./mdexplore.sh --mermaid-backend rust test/ARCHITECTURE.md
```

```
# 5) Open canonical large multi-diagram file (quoted path)
./mdexplore.sh --mermaid-backend rust "test/2026-02-25 RPF_Response_MCP_Propc
```

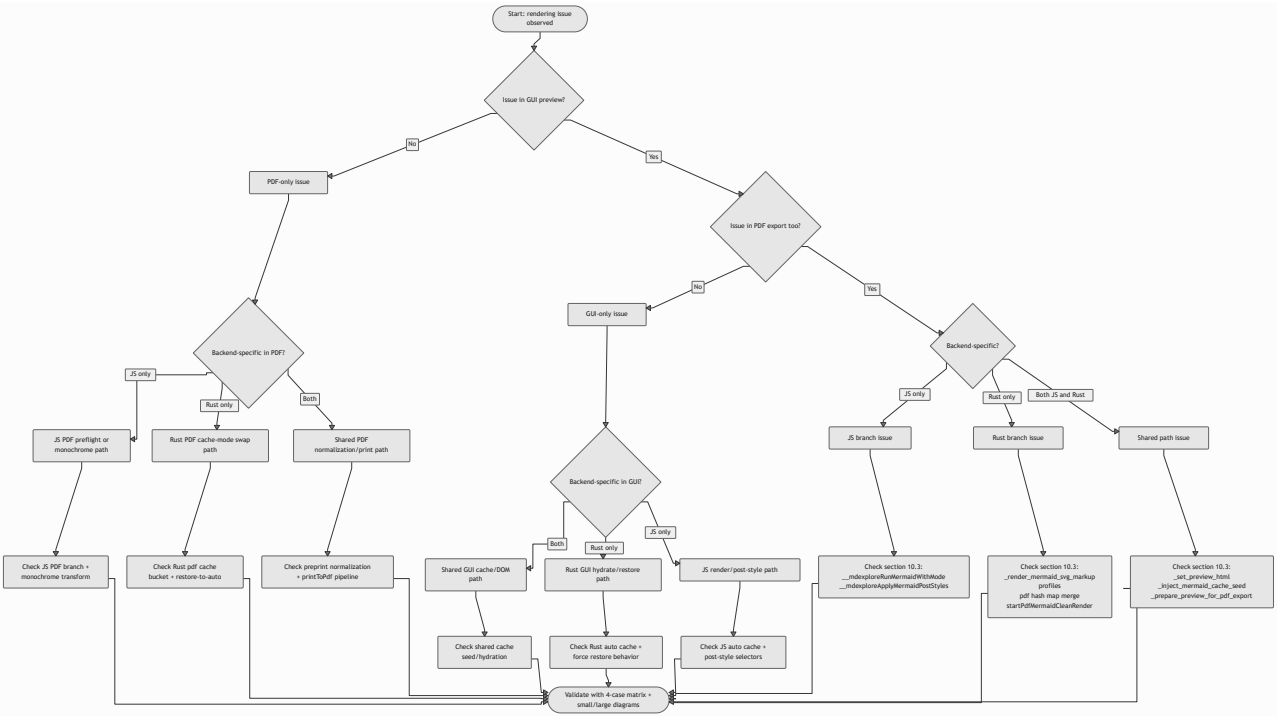
```
# 6) Fast quality gates after code edits
bash -n mdexplore.sh
python3 -m py_compile mdexplore.py
```

Standard Verification Sequence

For each backend (`js` , `rust`) and each file (small + large):

1. Open file and confirm GUI diagram colors/layout.
2. Export PDF and confirm PDF Mermaid path for that backend.
3. Return to GUI and confirm preview styling is restored.
4. Re-open same file in same app run and verify cache path still behaves.

Decision Tree



Immediate Red Flags

- Rust PDF output looks like GUI output.
  - likely mode mix-up (`auto` used where `pdf` expected).
- GUI remains white/print-styled after PDF export.
  - likely restore-to- `auto` did not reapply.
- Mermaid in PDF is tiny relative to page width.
  - likely width/height attr normalization incomplete.
- Only large diagrams fail.
  - likely `setHtml` payload/temporary-file load path and timing interactions.

1. Scope and Intent

`mdexplore` has multiple render branches:

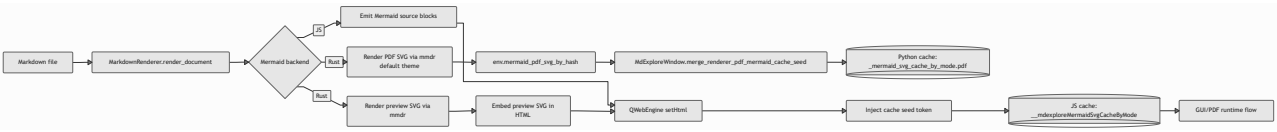
- GUI preview vs PDF export mode.
- Mermaid JS backend vs Rust Mermaid backend (`mmdr`).
- Python-side render/cache responsibilities vs in-page JavaScript responsibilities.

The main maintenance risk is crossing these concerns and accidentally reusing the wrong SVG variant (for example reusing GUI-adjusted SVGs in PDF mode).

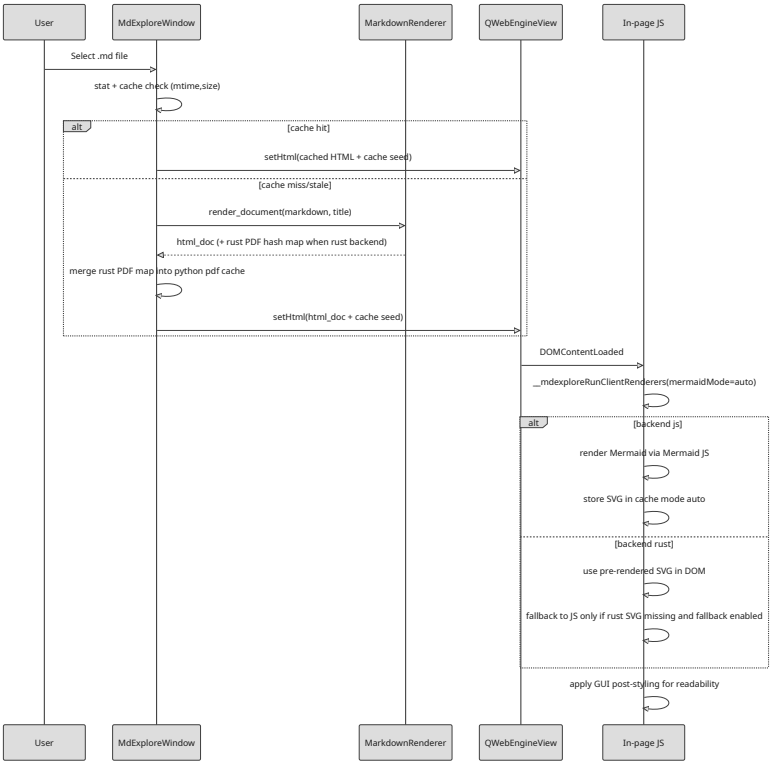
2. Render Mode Matrix

Mode	Mermaid Backend	SVG Source	Post-processing	Primary Cache Bucket
GUI	JS	Mermaid JS runtime (`mermaid.render`)	GUI contrast/style tuning	`auto`
GUI	Rust	`mmdr` preview profile (Python)	GUI contrast/style tuning	`auto`
PDF	JS	Mermaid JS runtime in PDF preflight	print monochrome/grayscale transform	`pdf`
PDF	Rust	`mmdr` PDF profile (default theme, Python)	print-safe grayscale normalization (multi-shade)	`pdf`

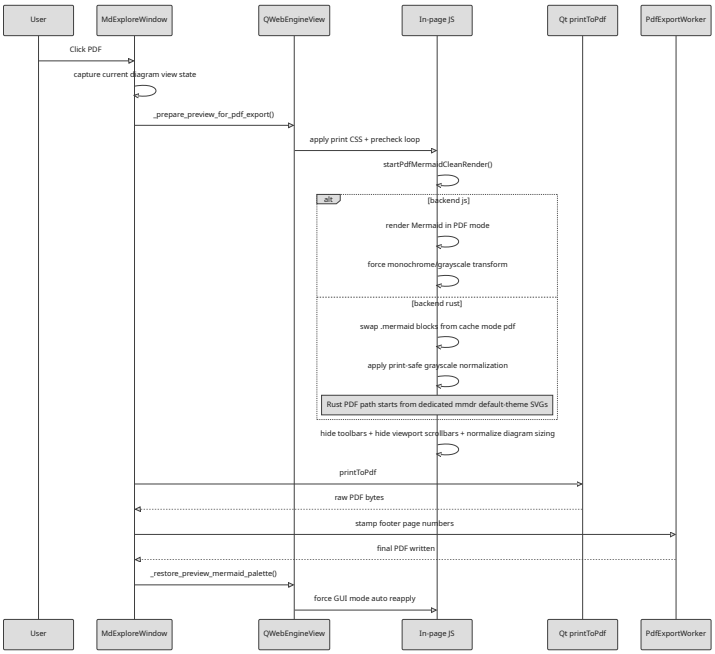
3. End-to-End Ownership



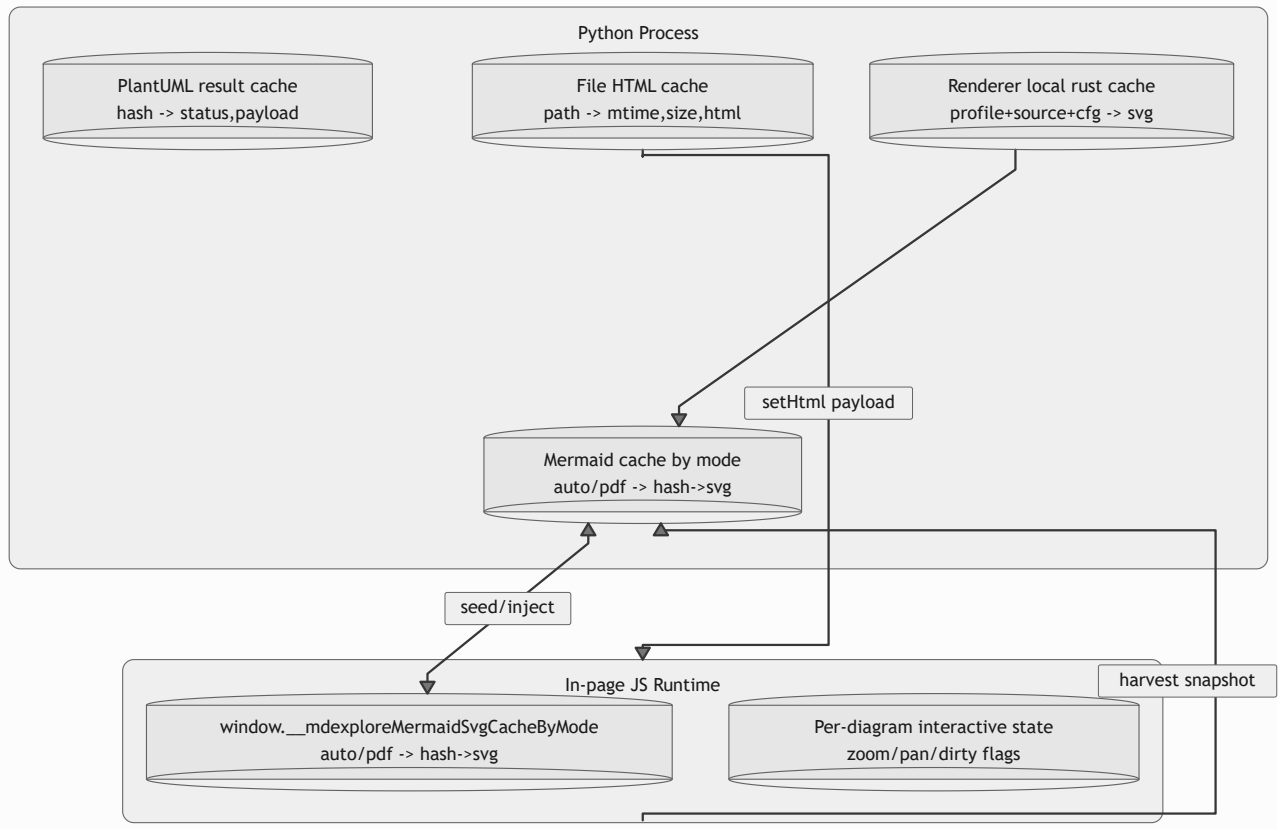
4. GUI Preview Path



5. PDF Export Path


User
MdExploreWindow
QWebEngineView
In-page JS
Qt printToPdf
PdfExportWorker
Click PDF
capture current diagram view state
_prepare_preview_for_pdf_export()
apply print CSS + precheck loop
startPdfMermaidCleanRender()
alt
[backend js]
render Mermaid in PDF mode
force monochrome/grayscale transform
[backend rust]
swap .mermaid blocks from cache mode pdf
apply print-safe grayscale normalization
Rust PDF path starts from dedicated mmdr default-theme SVGs
hide toolbars + hide viewport scrollbars + normalize diagram sizing
printToPdf
raw PDF bytes
stamp footer page numbers
final PDF written
_restore_preview_mermaid_palette()
force GUI mode auto reapply
User
MdExploreWindow
QWebEngineView
In-page JS
Qt printToPdf
PdfExportWorker

6. Cache Architecture



7. Critical Invariants

- Keep Mermaid cache separation by mode (`auto` vs `pdf`).
- Rust PDF output must come from the dedicated Rust PDF render profile, not GUI SVG.
- GUI Mermaid post-processing must not run on Rust PDF SVGs.
- Rust PDF path may apply print-safe grayscale normalization after selecting the dedicated Rust PDF SVG source.
- PDF preflight must hide interactive controls (toolbars/scrollbars) before snapshot.
- Post-export restore must force a GUI-mode reapply.

8. Failure and Fallback Rules

- Rust backend unavailable:
  - app falls back to JS backend and reports warning.
- Rust render missing SVG for a block:
  - GUI path may JS-fallback unless disabled for that operation.
  - PDF path reports explicit Mermaid failure for that block if no PDF SVG exists.
- PlantUML failure:
  - render placeholder becomes detailed error text; markdown stays visible.
- Stale cache safety:
  - file cache keyed by `mtime_ns` and `size` ; changed files are re-rendered.

9. Known TODO

- Diagram zoom/pan state restore across document switches is still not fully reliable for all Mermaid/PlantUML navigation sequences in one app run.
- See `AGENTS.md` for attempted approaches and constraints.

10. Debugging Playbook (Human + Agent)

This section is a practical troubleshooting guide for render regressions. Use it when behavior deviates from expectations.

10.1 First Principles

- Always isolate by branch first:
  - GUI vs PDF.
  - Mermaid backend `js` vs `rust`.
  - Small diagram vs large diagram.
- Keep one variable changing per test run.
- Verify whether failure is:
  - source generation,
  - cache selection,
  - in-page transform,
  - restore after PDF.

10.2 Fast Isolation Matrix

Run these four cases on the same markdown file with Mermaid:

Case	Backend	Path	Expected
A	JS	GUI	dark-theme tuned Mermaid in preview
B	JS	PDF	monochrome/grayscale Mermaid in PDF
C	Rust	GUI	dark-theme tuned Mermaid in preview
D	Rust	PDF	dedicated Rust PDF SVG + print-safe grayscale normalization

If only one case fails, debug that branch first.
If all fail, suspect shared setup (asset loading, cache seed injection, or broken JS runtime).

10.3 Key Code Waypoints

Use these anchors in `mdexplore.py` while debugging:

- Mermaid render profile split:
  - `MarkdownRenderer._render_mermaid_svg_markup(..., render_profile=...)`
- Rust PDF SVG capture:

    - `env["mermaid_pdf_svg_by_hash"]` in `render_document()`
    - `take_last_mermaid_pdf_svg_by_hash()`
    - `MdExploreWindow._merge_renderer_pdf_mermaid_cache_seed()`
- HTML injection path:
    - `_inject_mermaid_cache_seed(...)`
- In-page runtime orchestration:
    - `window.__mdexploreRunMermaidWithMode(...)`
    - `startPdfMermaidCleanRender(...)`
    - `window.__mdexploreApplyMermaidPostStyles(...)`
- PDF mode entry/exit:
    - `_prepare_preview_for_pdf_export(...)`
    - `_trigger_pdf_print(...)`
    - `_restore_preview_mermaid_palette(...)`

10.4 Symptom -> Likely Cause -> Next Check

Symptom	Likely Cause	Next Check
Rust PDF still shows GUI colors	wrong SVG source reused	verify Rust PDF path is pulling cache mode `pdf`, not current DOM
GUI stays white after PDF (Rust)	restore did not reapply `auto` SVG	verify `_restore_preview_mermaid_palette` forces mode `auto` and Rust branch honors `force`
PDF Mermaid tiny on page	width/height attrs not normalized	verify print preflight strips width/height attrs and sets width/max-width/height
GUI Mermaid labels too dark	post-style function missed selector class	inspect `__mdexploreApplyMermaidPostStyles` for diagram-kind-specific logic
Random “Preview load failed” on heavy files	`setHtml` payload too large / transient web load issue	verify temp-file fallback path in `_set_preview_html` and check status/log output
Rust fallback unexpectedly using JS in PDF	fallback guard missing in PDF stage	verify Rust PDF branch does not trigger JS fallback render path
Sequence diagram labels invisible in PDF	label content not normalized to dark text	verify grayscale pass handles both SVG text and foreignObject HTML labels

10.5 Runtime Inspection Steps (Inside Running App)

When the preview is open, inspect these JS objects from the page context:

- `window.__mdexploreMermaidBackend`
- `window.__mdexploreMermaidSvgCacheByMode`
- `window.__mdexploreMermaidPaletteMode`
- `window.__mdexplorePdfMermaidReady`
- `window.__mdexplorePdfMermaidError`

Pedagogical check sequence:

1. Confirm backend matches intent (`js` or `rust`).
2. Confirm both cache buckets exist (`auto` and `pdf`).
3. Confirm target diagram hash exists in expected bucket.
4. Confirm SVG payload in that bucket actually contains `<svg` .
5. Confirm active Mermaid mode (`auto` / `pdf`) matches current operation.

10.6 Cache and Ownership Sanity Rules

Treat these as hard assertions:

- Python cache ownership:
  - source of truth for injected seed snapshot at page load.
- JS cache ownership:
  - source of truth for in-page re-render/re-hydrate operations.
- Cross-mode safety:
  - `auto` and `pdf` caches must never be mixed.
- Rust profile safety:
  - preview profile output and PDF profile output are intentionally different artifacts.

10.7 Practical Reproduction Protocol

Use this exact sequence to reproduce and verify fixes:

1. Launch with JS backend and test one file (`GUI -> PDF -> GUI`).
2. Launch with Rust backend and repeat same file (`GUI -> PDF -> GUI`).
3. Repeat with:

- one small Mermaid diagram file,
- one large multi-diagram file.

4. For Rust, verify:

- GUI returns to dark-tuned view after PDF export,
- PDF starts from dedicated Rust PDF SVGs and remains readable after grayscale normalization.

5. Re-open the file in same app session and ensure cache path still behaves.

10.8 Logging and Instrumentation Strategy

When uncertain, add temporary, narrow logging at branch points:

- entering/exiting PDF mode,
- selecting Mermaid mode (`auto` / `pdf`),
- backend switch (`js` / `rust`),
- hash lookup misses per mode,
- restore completion path.

Remove or gate verbose logs after confirming the fix.

10.9 Acceptance Criteria for Render Fixes

A Mermaid/PDF fix is complete only when all are true:

- No regression in JS GUI preview.
- No regression in Rust GUI preview.
- JS PDF still produces readable print-safe output.
- Rust PDF uses dedicated Rust PDF SVG path before grayscale normalization.
- GUI view restores correctly after PDF export.
- Behavior holds for both small and large diagrams.
- Documentation (`README.md` , `AGENTS.md` , `RENDER-PATHS.md`) reflects the final path.