Marlin renderer

a successful fork and join the OpenJDK 9 project

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OpenJDK

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Outline

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Context

Java2D is a great API (since 1997) to perform graphics rendering.

Antialiasing renderers = Graphics2D.draw/fill(Shape):
- Ductus (closed-source) in Sun / Oracle JDK (jdk 1.2)
  - sun.dc.DuctusRenderingEngine (native C code)
- Pisces (open-source) integrated in OpenJDK (2007)
  - java2d.pisces.PiscesRenderingEngine (java)

Status in 2013:
- Ductus: faster but does not scale well (multi-threading)
- Pisces: slower but scales better
- GPU ? java2D pipelines (OpenGL, D3D...) provide only few accelerated operations (or switch to glg2d)
- JavaFX only for client applications (not server-side)
Marlin renderer = OpenJDK’s Pisces fork

- March-Mai 2013: my first patches to OpenJDK 8:
  ▶ Pisces patches to 2d-dev@openjdk.java.net: too late
  ▶ small interest / few feedback
- Andréa Aimé (GeoServer team) pushed me to go on:
  ▶ new MapBench tool: serialize & replay map rendering
  ▶ fork OpenJDK’s Pisces as a new open-source project

⇒ 01/2014: Marlin renderer & MapBench projects on github (GPL v2) with only 2 contributors (Me and Andrea Aimé)!

- https://github.com/bourgesl/marlin-renderer
  ▶ branch 'useUnsafe': trunk
  ▶ branch 'openjdk': in synch with OpenJDK9
- https://github.com/bourgesl/mapbench
Marlin & MapBench projects at github

Objectives:
- faster alternative with very good scalability
- improve rendering quality
- Compatible with both Oracle & Open JDK 7 / 8 / 9

Very big personal work:
- many releases in 2014: see releases
- Test Driven Development:
  - regression: MapDisplay (diff pisces / marlin outputs)
  - performance: MapBench & GeoServer benchmarks (+ oprofile)
- Important feedback within the GIS community: GeoServer (web), gvSIG CE (Swing) providing complex use cases & testing releases
Point cloud rendering in gvSIG CE

- Marlin allows parallel rendering of large point clouds (100M):
Marlin project on the web

- Famous blog post (02.2014): Achieving Extreme GeoServer Scalability with the new Marlin vector rasterizer

- Marlin wiki: Benchmarks page
Late 2014: several mails to 2d-dev@openjdk.java.net

FOSDEM 2015: discussion with OpenJDK managers (Dalibor & Mario) on how to contribute the Marlin renderer back

⇒ I joined the graphics-rasterizer project in march 2015 to contribute Marlin as a new standalone renderer for OpenJDK9.

I worked hard (single coder) with Jim Graham & Phil Race (reviewers) between march 2015 to december 2015 (4 big patches)

We proposed the 'JEP 265: Marlin Graphics Renderer’ in July 2015 and make it completed!

⇒ It is now integrated in OpenJDK9 b96 ⇒ Marlin even faster:
  ▶ Marlin 0.7: improve coordinate rounding arround subpixel center
  ▶ Marlin 0.7.2: improve large pixel chunk copies (coverage data)
My feedback on contributing to OpenJDK

- Very interesting & many things learnt
- License issue: OCA for all contributors, no third-party code!
- Webrev process: great but heavy task:
  - create webrevs (hg status, webrev.ksh with options)
  - push on cr.openjdk.java.net/~<mylogin>/
  - long discussions on mailing lists for my patches (50 mails)
  - timezone issue: delays + no skype
- Few Java2D / computer graphics skills = small field + NO DOC!

General:
- CI: missing ‘open’ multi-platform machines to perform tests & benchmarks outside of Oracle
- Funding community-driven effort? support collaboration with outsiders
How Java2D works?

Java2D uses only 1 RenderingEngine implementation at runtime:

- SunGraphics2D.draw/fill(shape)
- AAShapePipe.renderPath(shape, stroke)
  - aatg = RenderingEngine.getAATileGenerator(shape, at)
    - Coverage mask computation (tiles) as alpha transparency [0-255]
    - aatg.getAlpha(byte[] alpha, ...) to get next tile ...
  - output pipeline.renderPathTile(byte[] alpha):
    - MaskFill operations (software / OpenGL pipeline) on dest surface

```
RenderingEngine:
    public static synchronized RenderingEngine getInstance();
    public AATileGenerator getAATileGenerator(Shape s,
                                              AffineTransform at, ...);

AATileGenerator:
    public int getTypicalAlpha();
    public void nextTile();
    public void getAlpha(byte tile[], ...);
```
How Marlin works? Pisces / Marlin pipeline

MarlinRenderingEngine.getAATileGenerator(shape, stroke...):

- use shape.getPathIterator() ⇒ apply the pipeline to path elements:
- Dasher (optional):
  - generates path dashes (curved or segments)
- Stroker (optional):
  - generates edges around every path element
  - generates edges for decorations (cap & joins)
- Renderer:
  - curve decimation into line segments
  - addLine: basic clipping + convert float to subpixel coordinates
  - determine the shape bounding box
  - perform edge rendering into tile strides ie compute pixel coverages
  - fill the MarlinCache with pixel coverages as byte[] (alpha)
- MarlinTileGenerator:
  - provide tile data (32x32) from MarlinCache (packed byte[])
How Marlin works? the AA algorithm

- Scanline algorithm [8x8 supersampling] to estimate pixel coverages
  - Active Edge table (AET) variant with "java" pointers (integer-based)
- sort edges at each scanline
- estimate subpixel coverage and accumulate in the alpha row
- Once a pixel row is done: copy pixel coverages into cache
- Once 32 (tile height) pixel rows are done: perform blending & repeat!
Marlin performance optimizations

Intially GC allocation issue:
- Many growing arrays + zero-fill
- Many arrays involved to store edge data, alpha pixel row ...
- Value-Types may be very helpful: manually coded here!

RendererContext (TL/CLQ) = reused memory ⇒ almost no GC:
- kept by weak / soft reference
- class instances + initial arrays takes 512Kb
- weak-referenced array cache for larger arrays

Use:
- Unsafe: allocate/free memory + less bound checks
- zero-fill (recycle arrays) on used parts only!
- use dirty arrays when possible: C like!
Marlin performance optimizations

- Need good profiler: use oprofile + gather internal metrics

- Fine tuning of Pisces algorithms:
  - custom rounding [float to int]
  - DDA in Renderer with correct pixel center handling
  - tile stride approach instead of all tiles (32px)
  - pixel alpha transfers (RLE) ⇒ adaptive approach

All lot more...
MapBench benchmarks

- MapBench tool:
  - a multi-threaded java2d benchmark that replays serialized graphics commands (see ShapeDumperGraphics2D)
  - calibration & warmup phase at startup + correct statistics [min, median, average, 95th percentile, max]

Procedure:

- disable HyperThreading (in BIOS)
- use fixed cpu frequencies (2GHz) on my laptop (i7 4800)
- setup the jvm: jdk to use + basic jvm settings = CMS gc 2Gb Heap
- use a profile (shared images) to reduce GC overhead

⇒ Reduce variability (and cpu affinity issues)
Before Marlin

Pisces vs Ductus (jdk 1.8_60)

Test Name - Number of threads

ductus_20160122.log pisces_20160122.log
With Marlin

Marlin vs Pisces vs Ductus (jdk 1.8_60)

Test Name - Number of threads

ductus_20160122.log  pisces_20160122.log  marlin_20160122.log
Performance summary

Marlin vs Pisces vs Ductus - Ratio (jdk 1.8_60)

Test Name - Number of threads

- ductus_20160122.log
- pisces_20160122.log
- marlin_20160122.log
VolatileImage issue

Marlin - Volatile vs Buffered Image - 95% time (jdk 1.8_60)

Test Name - Number of threads

- marlin_20160122_soft_tile6_last.log
- marlin_20160122_soft_tile6_accel.log
How to use Marlin?

See:
https://github.com/bourgesl/marlin-renderer/wiki/How-to-use

- Just download the latest Marlin release
- Start your java program with:
  - `-Dsun.java2d.renderer=sun.java2d.marlin.MarlinRenderingEngine`
  - Oracle or Open JDK 1.7 or 1.8 needed

- OR download any Oracle or Open JDK9 EA builds
  - [https://jdk9.java.net/](https://jdk9.java.net/)
Demo

Here is a demo comparing OpenJDK Pisces vs Marlin on intensive rendering tasks (based on MapBench) = MapDemo class!
Demo Performance summary

Marlin vs Pisces vs Ductus - FPS (jdk 1.8_60)

Test Name - Number of threads

- ductus_demo.log
- pisces_demo.log
- marlin_demo.log
Marlin renderer tuning

Marlin can be customized by using system properties:

- adjust subpixel sampling:
  - X/Y=3: [8x8] (by default)
  - smaller values are faster but less accurate
  - higher values are slower but more accurate
  - pixel sizing: typical largest shape width / height (2048 by default)

- adjust tile size: 6 [64x64] seems better than 5 [32x32]

Debugging:

- log statistics to know what happens
- enable checks if segfault or artefacts !
## Marlin System properties

<table>
<thead>
<tr>
<th>System property</th>
<th>values</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sun.java2d.renderer.useThreadLocal</td>
<td>true - false</td>
<td>RdrCtx in TL or CLQ (false)</td>
</tr>
<tr>
<td>sun.java2d.renderer.useRef</td>
<td>soft - weak - hard</td>
<td>Reference type to RdrCtx</td>
</tr>
<tr>
<td>sun.java2d.renderer.pixelsize</td>
<td>2048 in [64-32K]</td>
<td>Typical shape W/H in pixels</td>
</tr>
<tr>
<td>sun.java2d.renderer.subPixel_log2_X</td>
<td>3 in [1-8]</td>
<td>Subpixel count on X axis</td>
</tr>
<tr>
<td>sun.java2d.renderer.subPixel_log2_Y</td>
<td>3 in [1-8]</td>
<td>Subpixel count in Y axis</td>
</tr>
<tr>
<td>sun.java2d.renderer.tileSize_log2</td>
<td>5 in [3-8]</td>
<td>Pixel width/height for tiles</td>
</tr>
<tr>
<td>sun.java2d.renderer.doStats</td>
<td>true - false</td>
<td>Log rendering statistics</td>
</tr>
<tr>
<td>sun.java2d.renderer.doChecks</td>
<td>true - false</td>
<td>Perform array checks</td>
</tr>
<tr>
<td>sun.java2d.renderer.useLogger</td>
<td>true - false</td>
<td>Use j.u.l.Logger</td>
</tr>
</tbody>
</table>

Log2 for subpixel & tile sizes:

- subPixel = 3 means 8x8
- tileSize = 5 means 32x32
Future work

I may have still spare time to improve Marlin...

But your help is needed:

- try your applications & use cases with Marlin
- contribute: let’s implement new algorithms (gamma correction, clipping ...)
- provide feedback, please!
Quality Ideas

- NaN / Overflow handling
- Higher precision maths: double vs float in Dasher / Stroker maths and affine transforms

**Handle properly the gamma correction:** (MaskFill C macros)
  - very important for visual quality
  - note: stroke width must compensate the gamma correction to avoid having thin shapes.

- Analytical pixel coverage: using signed area coverage for a trapezoid
  ⇒ compute the exact pixel area covered by the polygon
Performance ideas

- **Clipping:**
  - implement early efficient path clipping (major impact on dashes)
  - take care of affine transforms (margin, not always rectangle)

- **Cap & join processing (Stroker):**
  - do not emit extra collinear points for squared cap & miter joins
  - improve Polygon Simplifier?

- **Scanline processing (8x8 subpixels):**
  - 8 scanlines per pixel row ⇒ compute exact area covered in 1 row
  - see algorithmic approach (AGG like):
  - may be almost as fast but a lot more precise!
That’s all folks!

- Please ask your questions
- or send them to marlin-renderer@googlegroups.com

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