MOBILE VECTOR CARTOGRAPHY

Designing For Infinite Scale Factors • NACIS 2014

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I'm very glad to be here. Like Ken Kato, I'm here from Oregon, but also a Pittsburgh native! Thanks for having me.

INTRODUCTION

- Engineering-focused talk (though from a carto perspective)
- Mapbox is building tools for designers & developers
  - Enabling more cartographers
  - Programming/design/combination
- As much about what we're building as what we've learned

This will be an engineering-heavy talk, relatively, but I hope it's useful for cartographers. I'd like to share what goes into some of the tools we make for people making maps.

THE JOURNEY SO FAR

- Raster-based ***tile*** design with tools like TileMill
  - Deterministic (at least in principle)
  - Technically limiting for large geographic focus
    - Quantity of tiles (generally need 1:1 scale-to-tile layer parity)
    - Inability to change cartography on the fly
    - Limited situational flexibility (rotation, localization, animation)

We're starting to move from design of tiles themselves, where the final, delivered product is rasterized imagery.

THE JOURNEY (CONT'D)

- Moving to vector-based ***style*** design with Mapbox Studio & GL
- Goal: still deterministic design (again, in principle)
- But offers new benefits
  - Lower number of tiles through overzooming of vector features
  - Ability to change style 60 times/second (FPS)
  - Rotation, label changes, interpolated style transitions all possible

We're moving to style design, where styles and data tiles are compiled to be rendered on the server. I say "in principle" because for the worldwide base maps that we're enabling, no one checks every corner of the globe. They need things to render predictably.

VECTOR…?

- Can refer to either or both sides of the stack
- Vector data: point & polyline features essentially as data on a grid
  - However, can still be rasterized into tiles, then served
- Vector rendering: live drawing of features on the client side
  - Every viewport change is an opportunity for re-render

We're mostly talking about vector rendering here, by way of converting data into a portable, compact, pre-tiled vector data format.

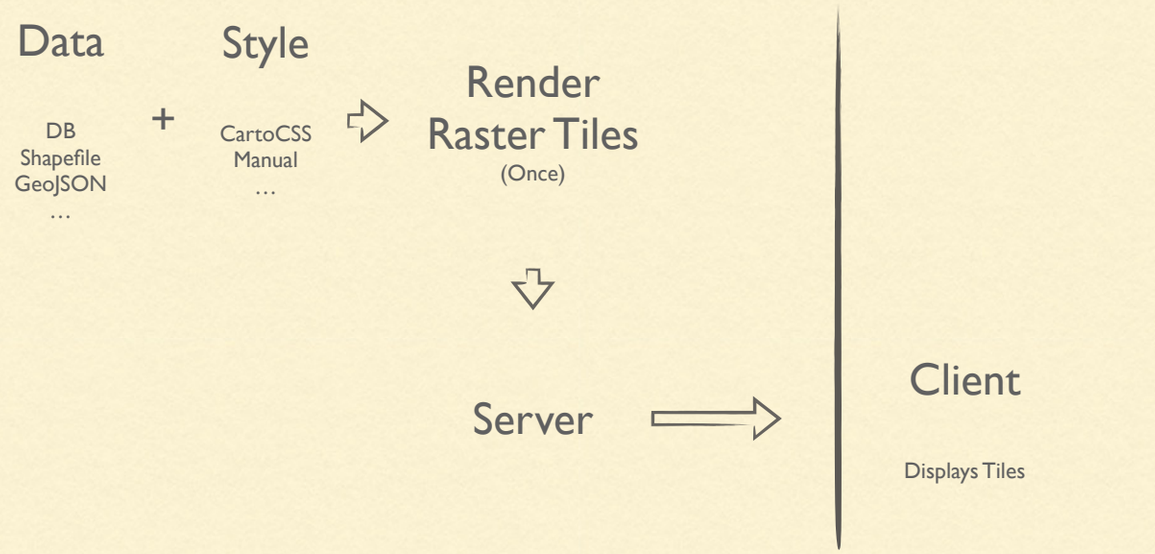
VECTOR RENDERING

- Approaches: in software (e.g. SVG) or in hardware (e.g. OpenGL)
- We went with OpenGL (hardware accelerated)
  - Based on a 22 year old API used for 3D visualizations & games
  - OpenGL ES (Embedded Systems) on mobile
  - Highly parallel & rapid processing of pixels on screen

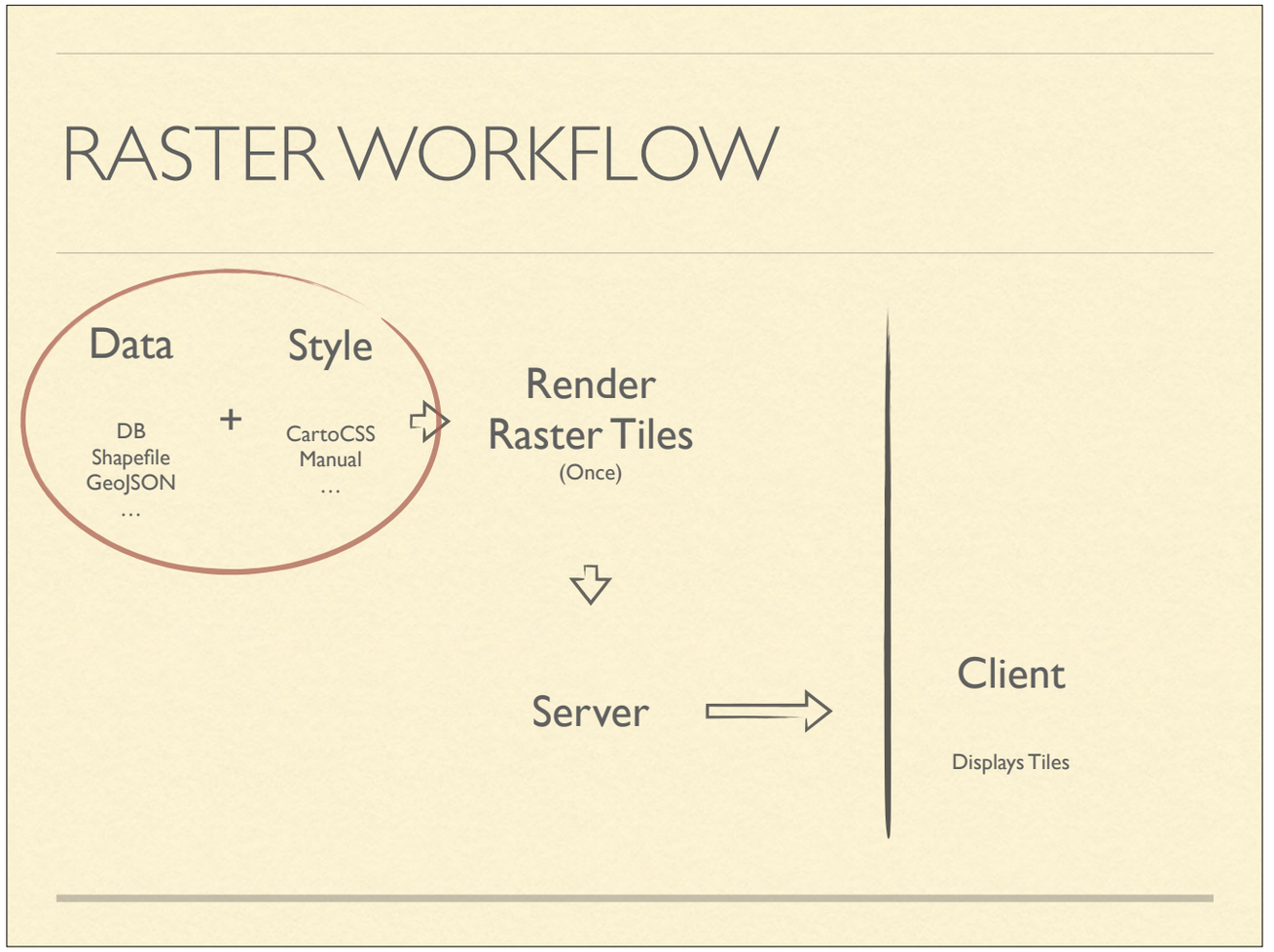
OPENGL TRADEOFFS

- Makes use of dedicated hardware (GPU)
  - Very good at its subset of capabilities
- Drawing work is offloaded from the CPU
  - Freed up for other tasks like network & disk activity
- But much more primitive & laborious (luckily, we do that part)
  - Bridges styling language to primitives like points & triangles

RASTER WORKFLOW



A wall is put up between cartographic control and the mobile device where the map is shown and used. The styling step happens on the left side of this wall.



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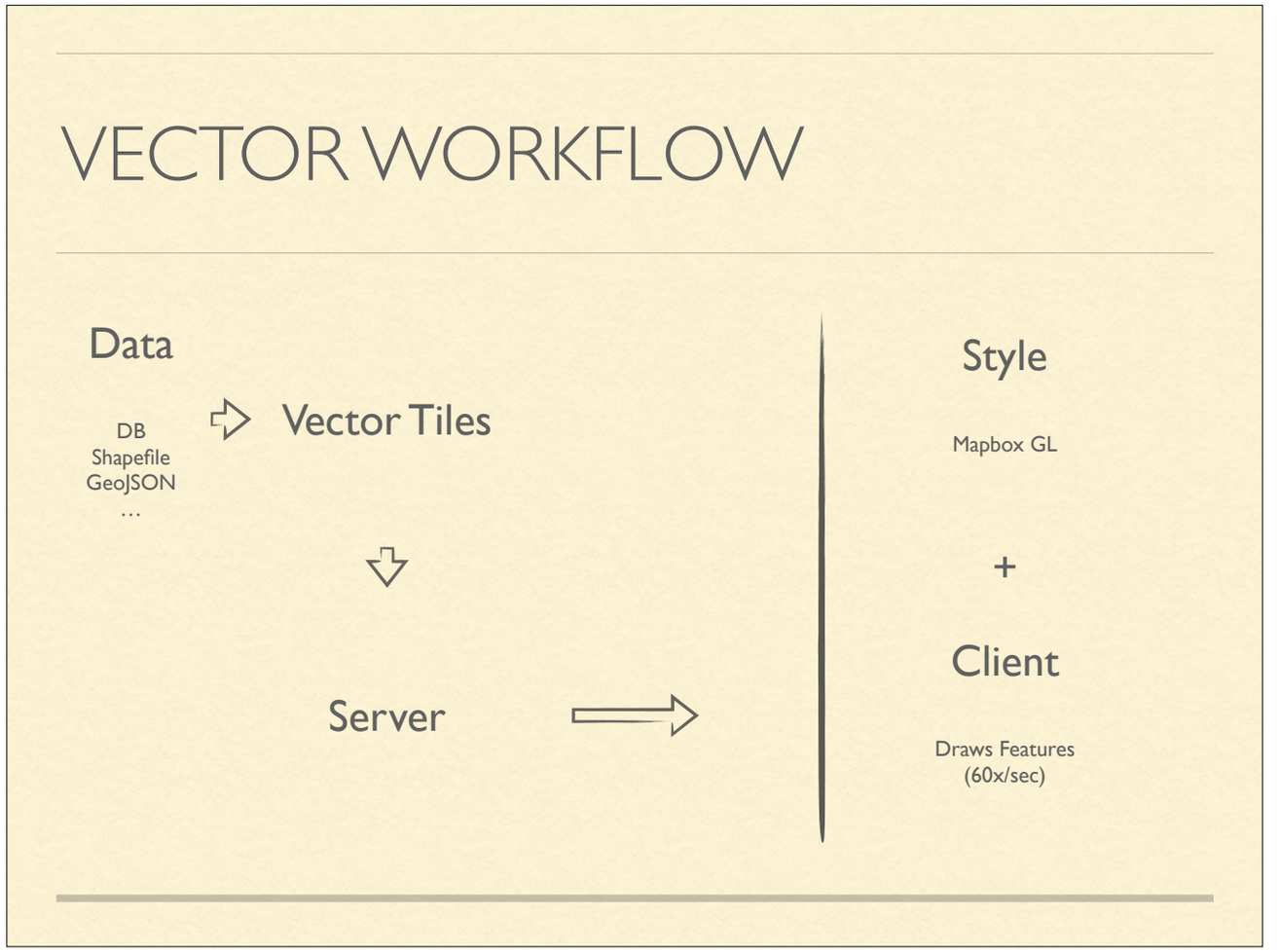
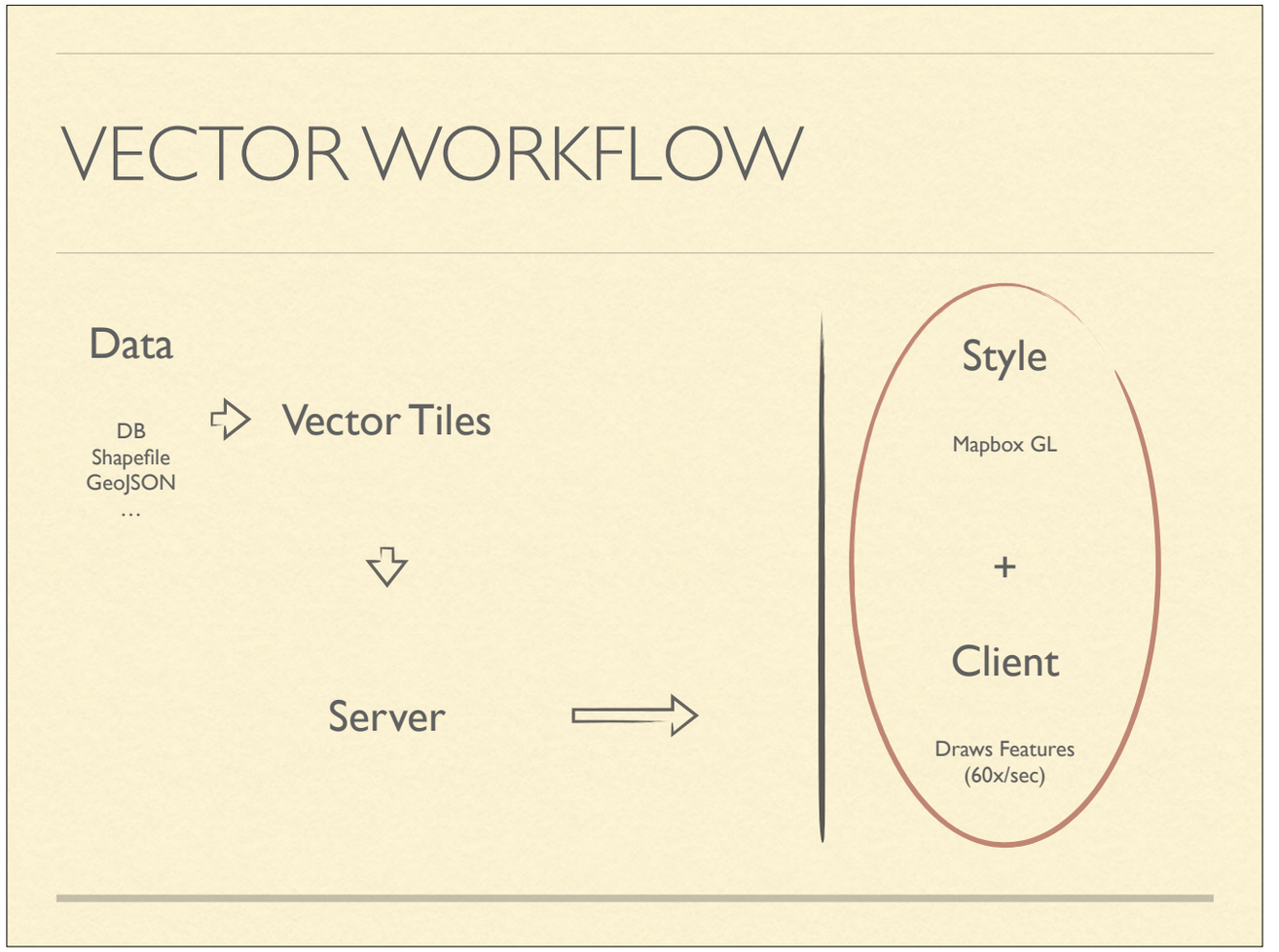


With vector rendering, opportunities exist on the right side of that wall to continue to change and respond to context when styling the map.



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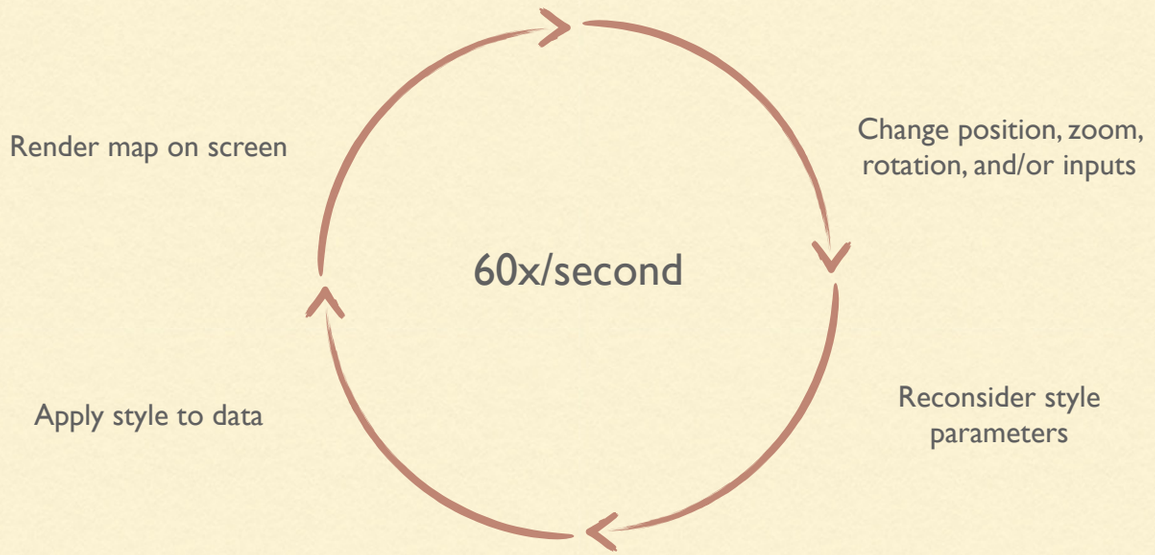
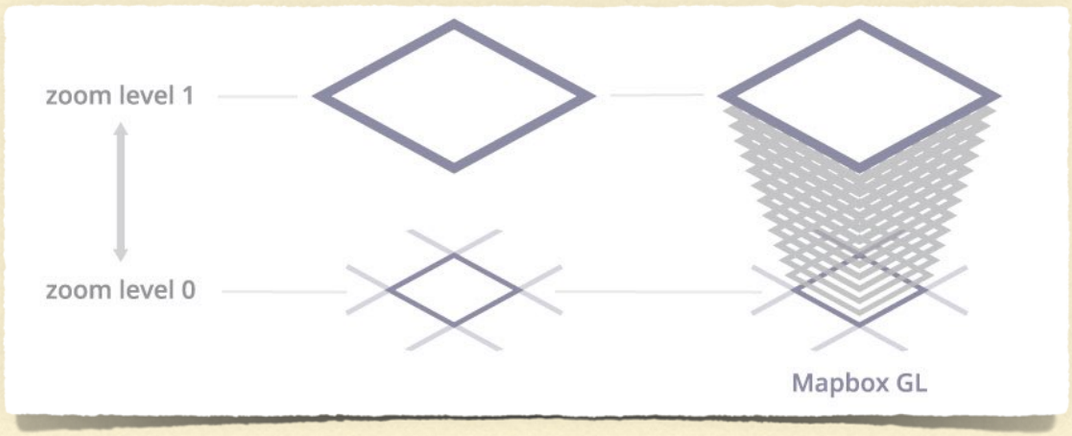
THE CIRCLE OF LIFE

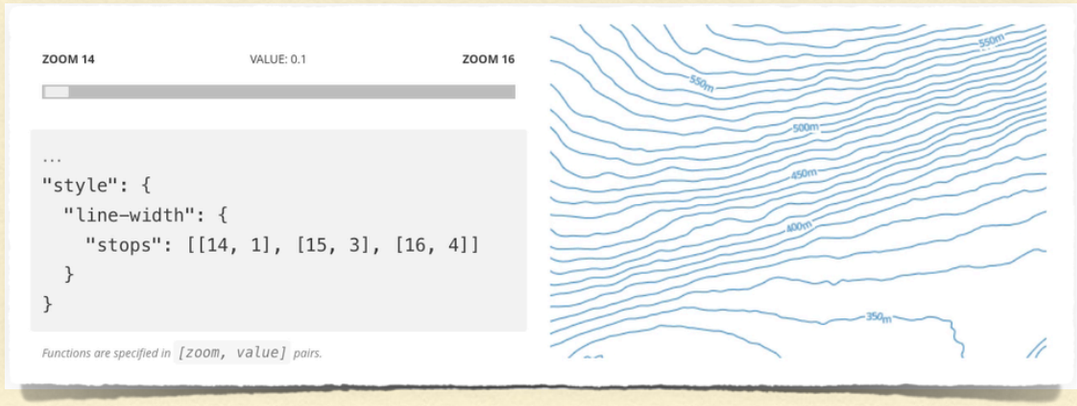


INCREMENTAL ZOOM



There are now incremental zoom levels, where every minor gesture creates a slightly new map scale that can be rendered uniquely.

ZOOM-DEPENDENT STYLING



In this example, line width is interpolated along a series of “stops” which describe pixel width against the current zoom level.

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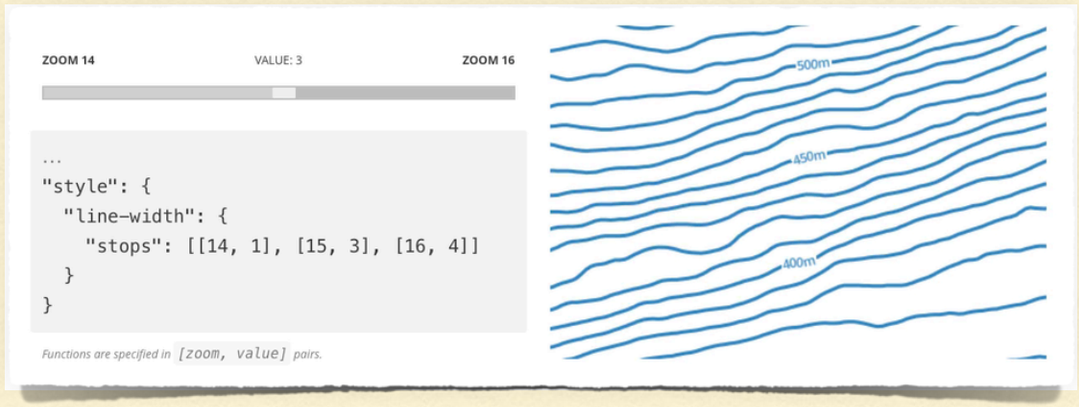

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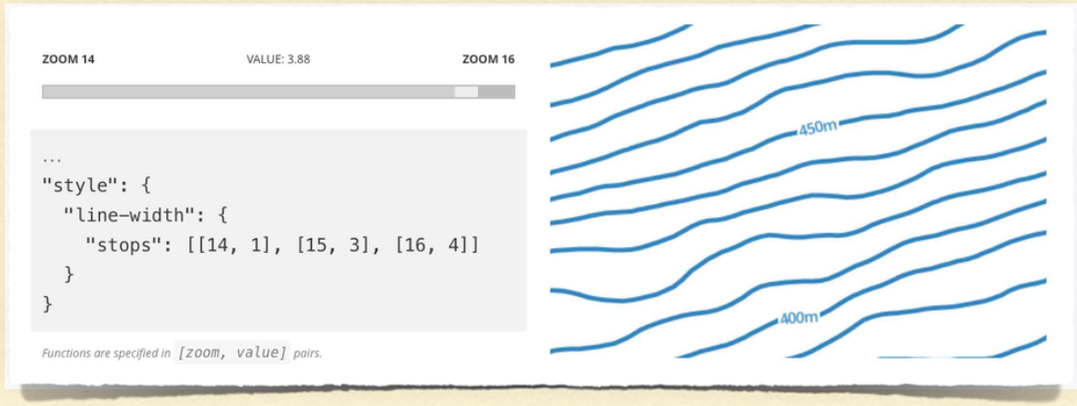

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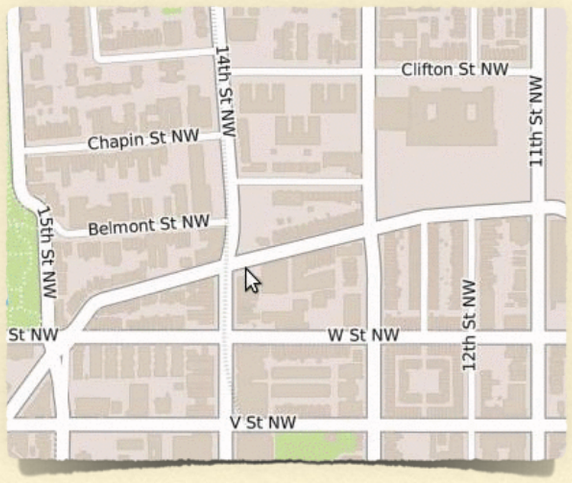
ZOOMING LABEL COLLISION



K. Been, E. Daiches, and C. Yap. *Dynamic map labeling.*, IEEE VGTC, Vol. 12, No. 5, 2006

Here we show how zooming label collision plays out.

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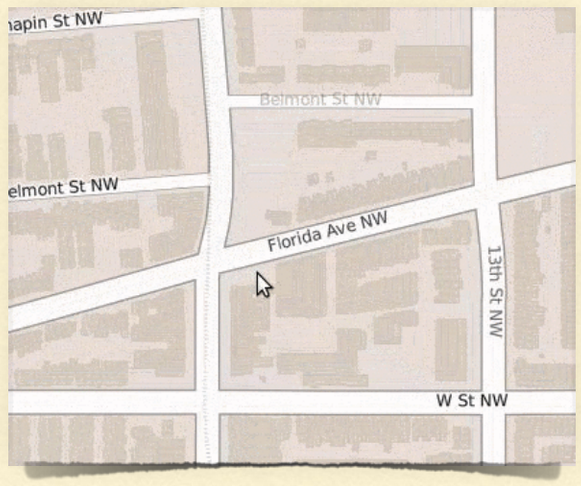

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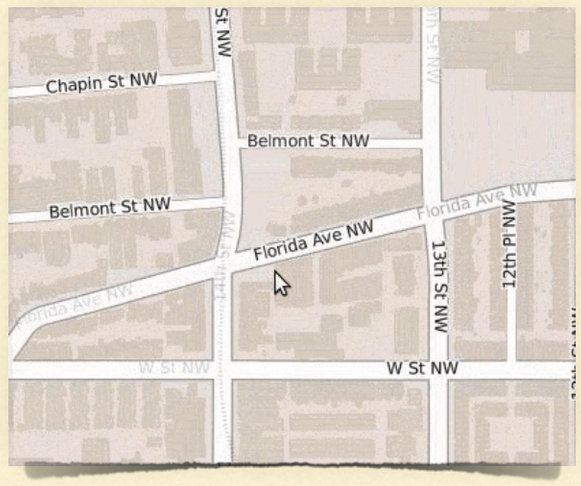

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ROTATION LABEL COLLISION

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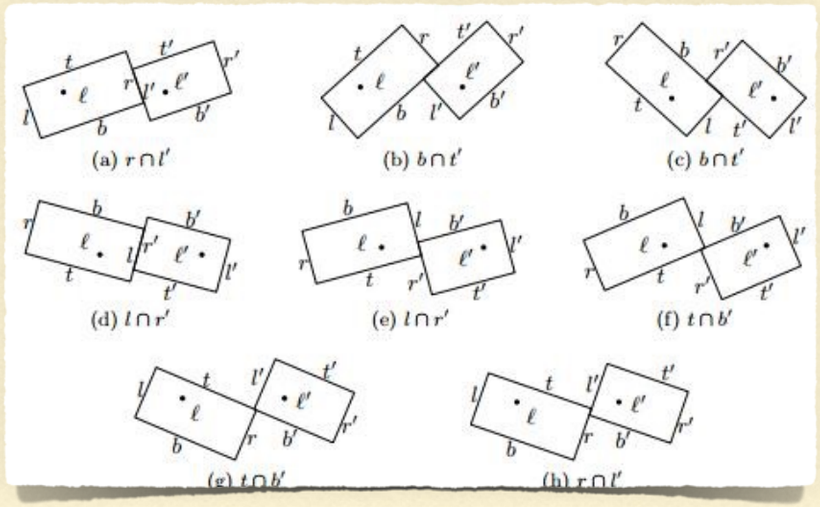
LABEL COLLISION SITUATIONS



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We used some computer graphics research to determine how to solve this collisions and always render legible and useful labels.

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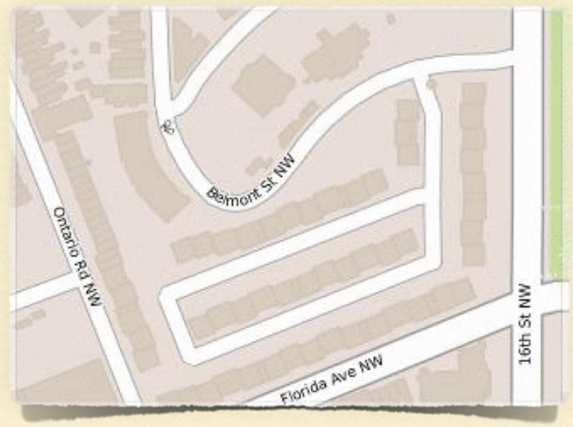

We’ve even gotten labels to wrap at angles which depend on the curvature of the map.

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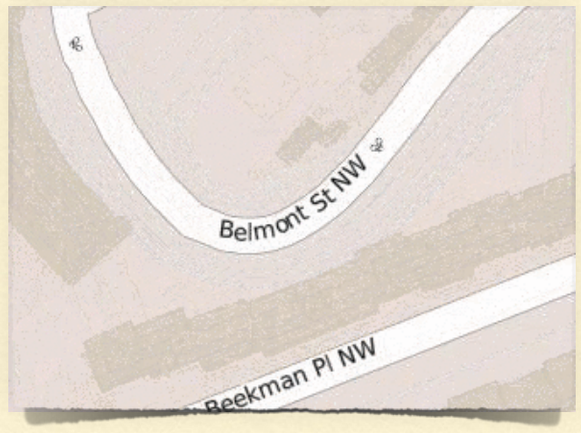

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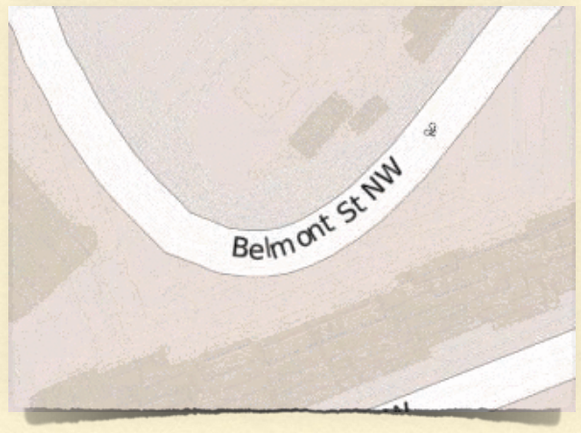

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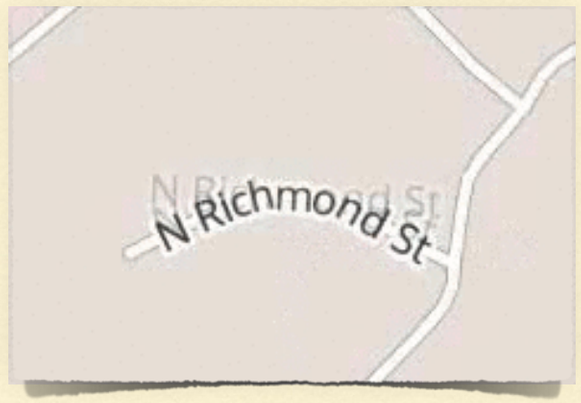

Here’s a look behind the scenes of how that is done.

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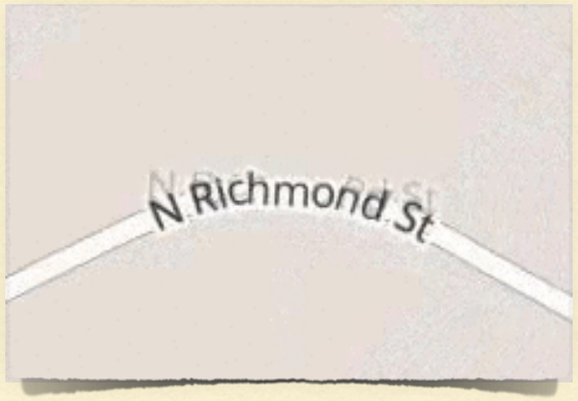

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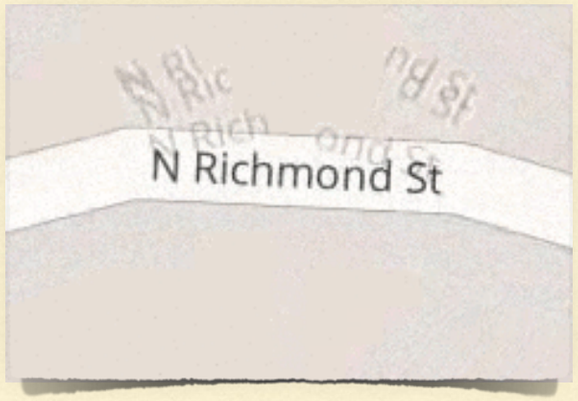

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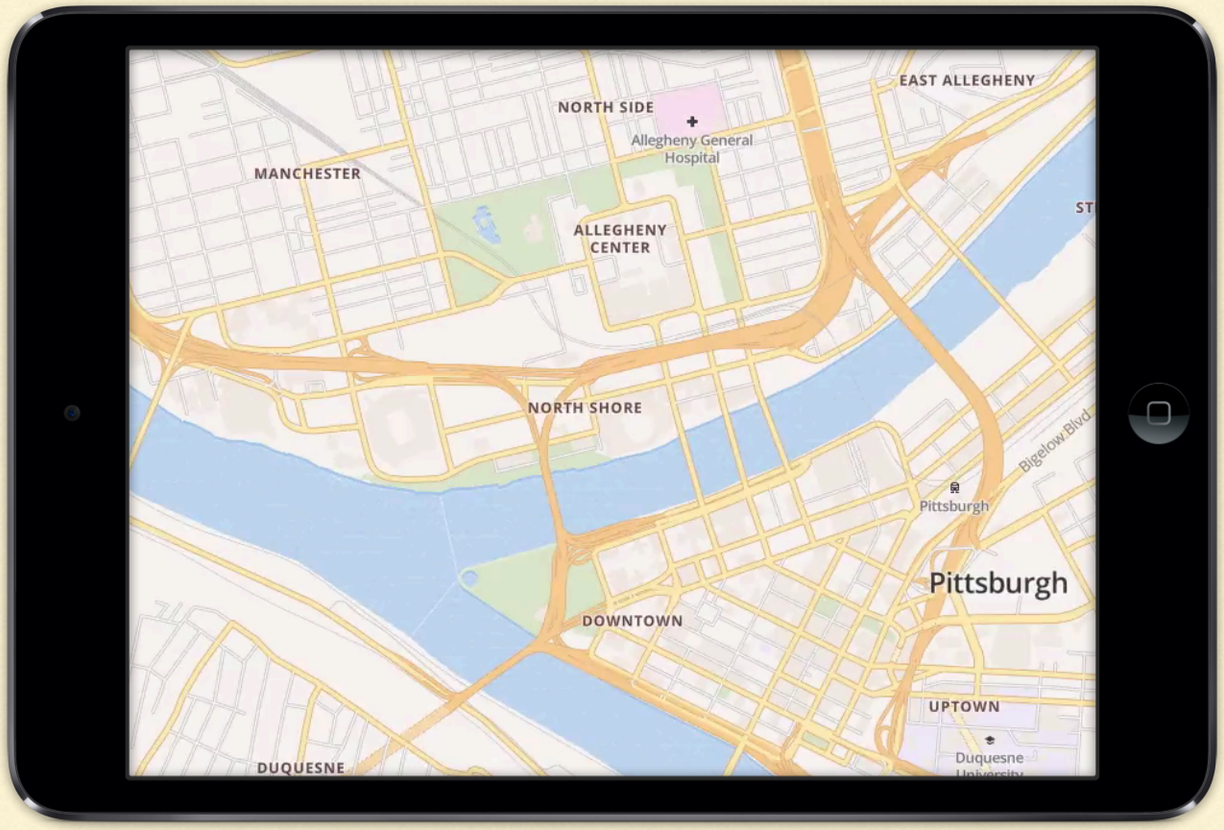
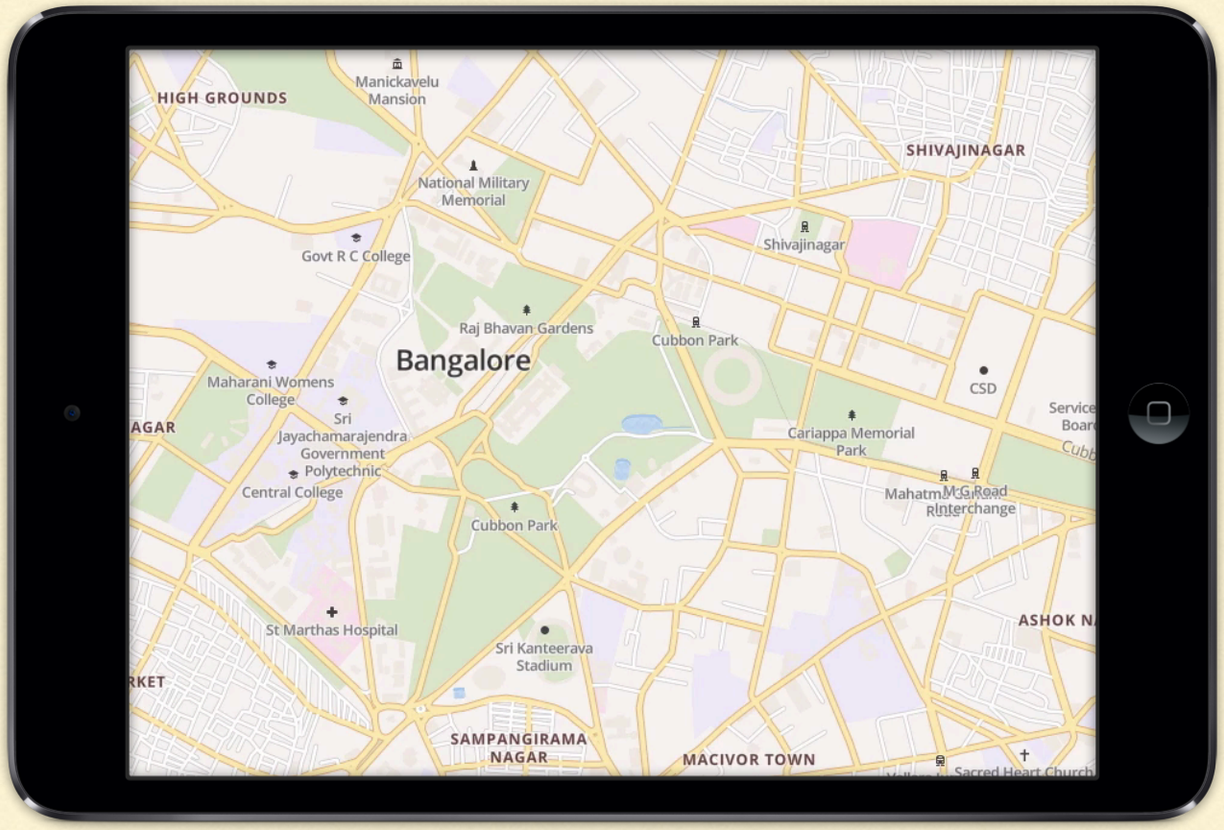


Labels should render the same in Pittsburgh, which you've planned for, as in Bangalore, which you may not have tested.



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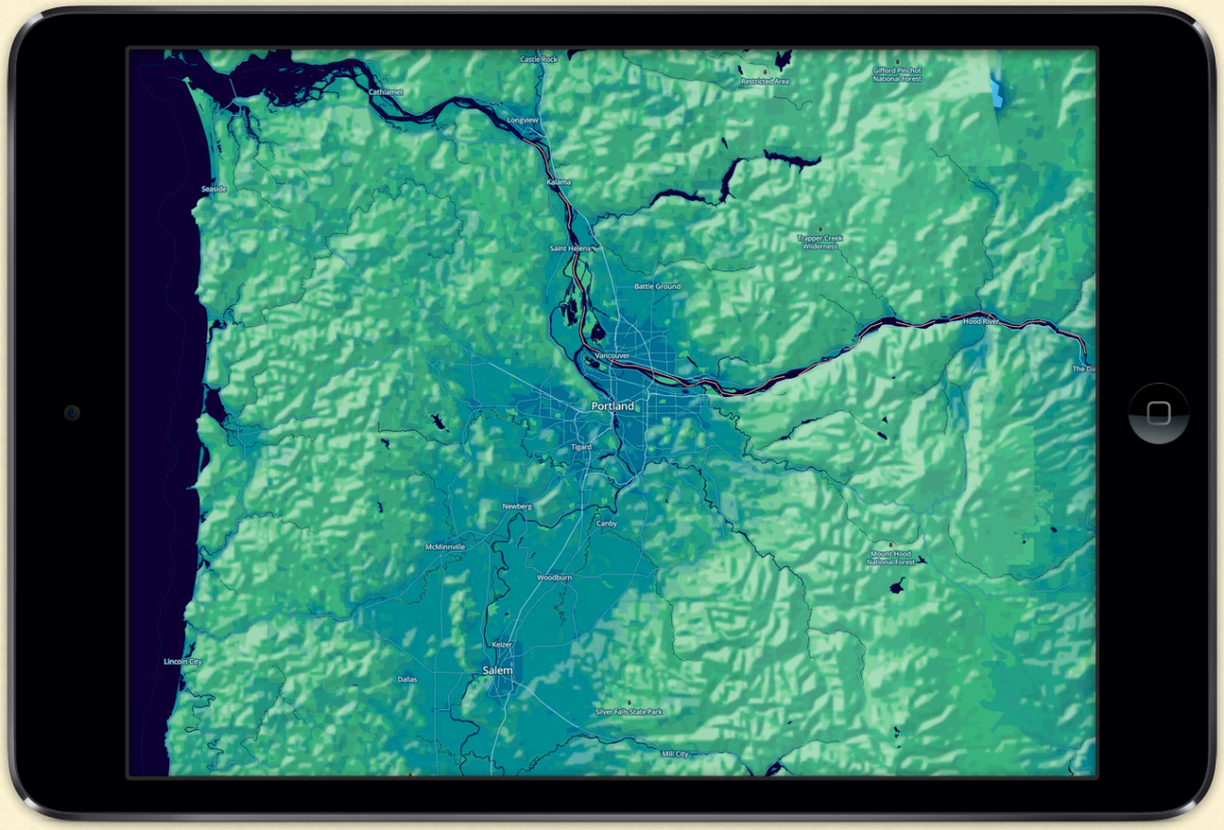

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Once you've got this foundation, even raster imagery can make use of it. Here is drone-collected aerial video imagery atop raster satellite tiles.

CONCLUSION

- We're building tools for the heavy lifting of hardware acceleration
- Combining pre-tiled vector data with flexible styling
- Oriented towards a more fluid, responsive map experience
- Hoping to create new potential for map design & interaction
- Open source & designed with interoperability in mind

THANK YOU

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