

Create / distribute tiled map

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Notes

- This presentation use some command line tools
 - Open following link in your browser.
 - Copy and paste the command line to your terminal.

https://smellman.github.io/jica_2024/

Self introduction

- GIS Engineer at Georepublic Japan
 - Programming: Python, JavaScript, TypeScript, Ruby etc.
 - UNIX and Linux guru
 - GIS skill: Data processing, Tiled based Map
- Community
 - Director of [OSGeo.JP](#)
 - Director of [OpenStreetMap Foundation Japan](#)
 - Sub president of [Japan Unix Society](#)
 - [UNOpenGIS/7](#) volunteer
- Contact: taro@georepublic.co.jp / @smellman on X

Today's agenda

- System setup
- What is tiled map?
- Introduction of software and data in this presentation
- How to create your own tiled map
- How to design your own tiled map
- How to distribute your own tiled map

System setup

- This presentation requires Linux based OS.
 - Use Raspberry Pi 4 in this seminar.

System setup - Connect your device

- Connect to SSID "vectortiles"
- Launch your browser
- Access following URL (seminar only)

<https://bit.ly/xxxx>

- Access to your host.

System setup - Install software

```
sudo apt install -y git make  
git clone https://github.com/smellman/jica_scripts.git  
cd jica_scripts/system  
sudo HOME=$HOME USER=$USER make install
```

What is tiled map?

Tile technology

- Provide map image or data over the internet.
 - Map images are separated as tiles.
 - Zoom Level 0 = World
 - Each zoom level doubles in the dimensions.
 - Too many tiles use "Web Mercator" projection.



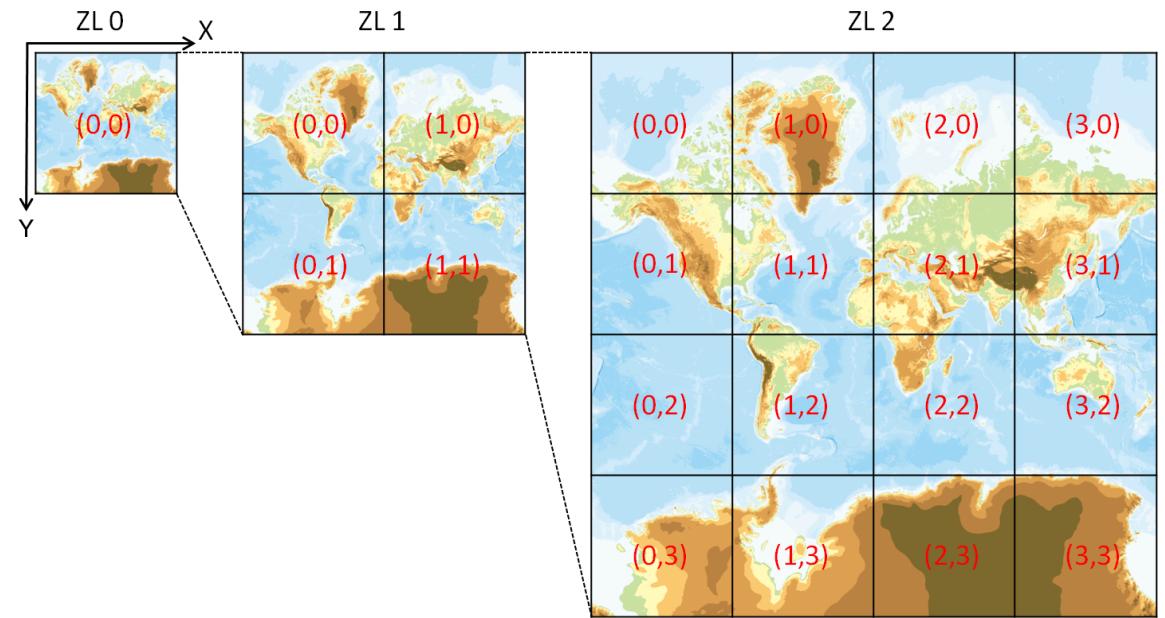
<https://a.tile.openstreetmap.org/0/0/0.png>

Useful to web

- Structure of tile is useful for web.
 - Enable to scroll map smoothly.
 - Enable to zoom up and zoom down map smoothly.
 - HTTP GET request.
- Tile become known for Google Maps.
 - Tile has existed from the late 1990s.

Zoom

- Zoom level 0 : 1 file
- Zoom level 1 : $2 \times 2 = 4$ files
- Zoom level 2 : $4 \times 4 = 16$ files
- ...
- Zoom level 18 : $2^{18} \times 2^{18} = 262,144 \times 262,144 = 68,719,476,736$ files



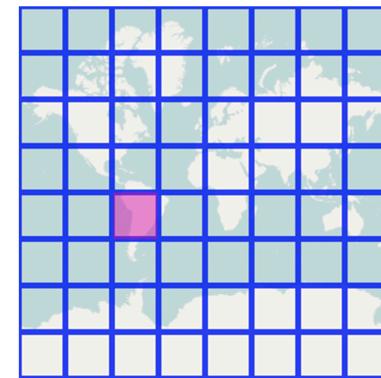
<https://maps.gsi.go.jp/help/image/tileNum.png>

GET Request

- Many services use REST API(GET Request).
 - `https://.../Z/X/Y.Format`
 - Z: Zoom Level
 - X: X coordinate
 - Y: Y coordinate
 - Format:
 - Raster image format(png, jpg, webp)
 - Vector data format(pbf, mvt)

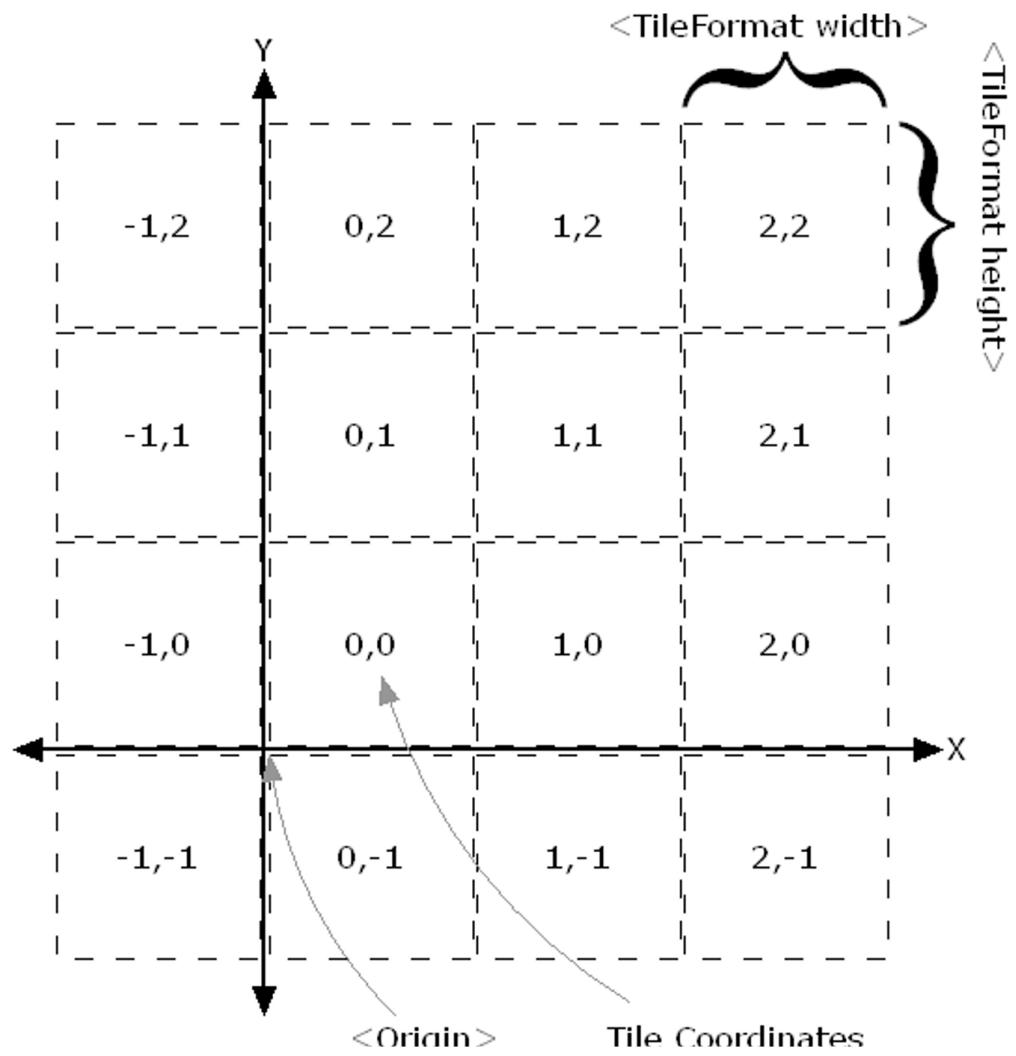
GET Request example

- <https://a.tile.openstreetmap.org/3/2/4.png>
 - Zoom = 3, X = 2, Y = 4,
format = png
 - X and Y coordinates start
with 0.

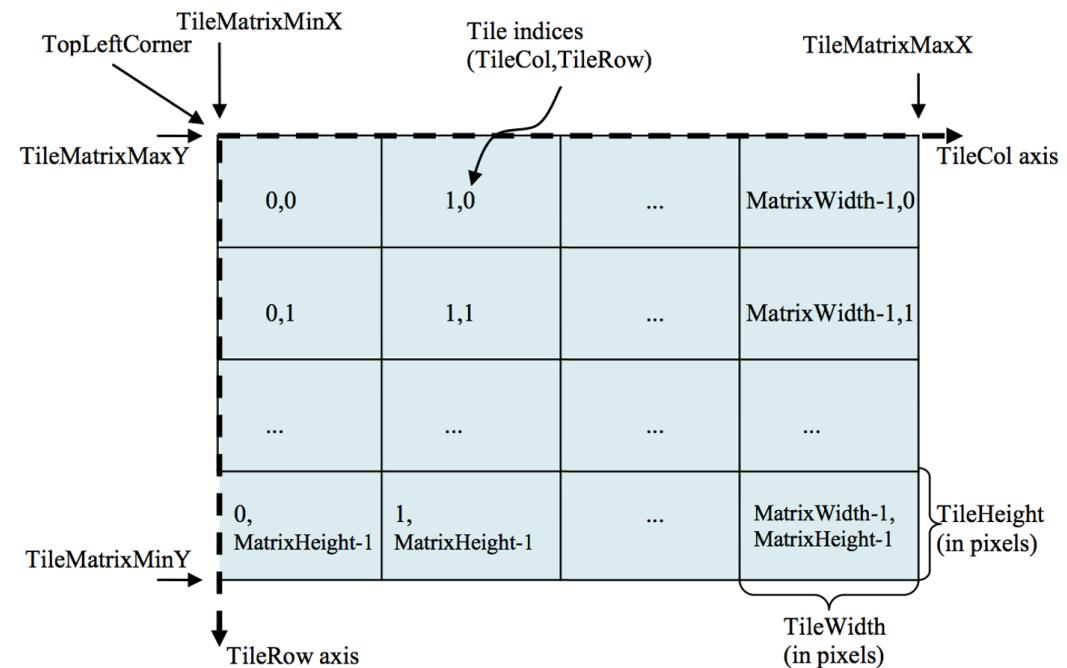


Specification

- Two tile service specifications are popular.
 - Tile Map Service(TMS)
 - Web Map Tile Service(WMTS)
- TMS is simpler than WMTS.
- TMS's X Y coordinate is started from bottom left.
 - Same as Cartesian coordinate system.
- WMTS's X Y coordinate is started from top left.
 - Same as Coordinate system of 2D computer graphics.



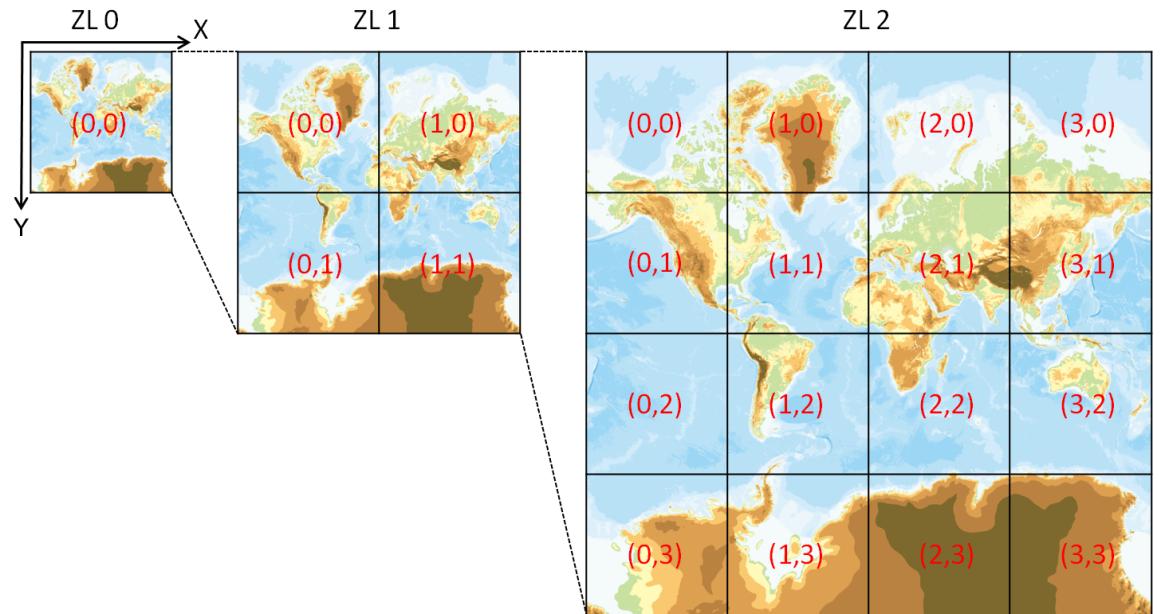
TMS



WMTS

The Y coordinate flipped

- OpenStreetMap use TMS like protocol but Y coordinate is numbered from top.
 - OpenStreetMap call "Slippy Map".
 - We call xyz tile.
 - $\{z\}/\{x\}/\{y\}.png$
 - Also we call zxy tile.

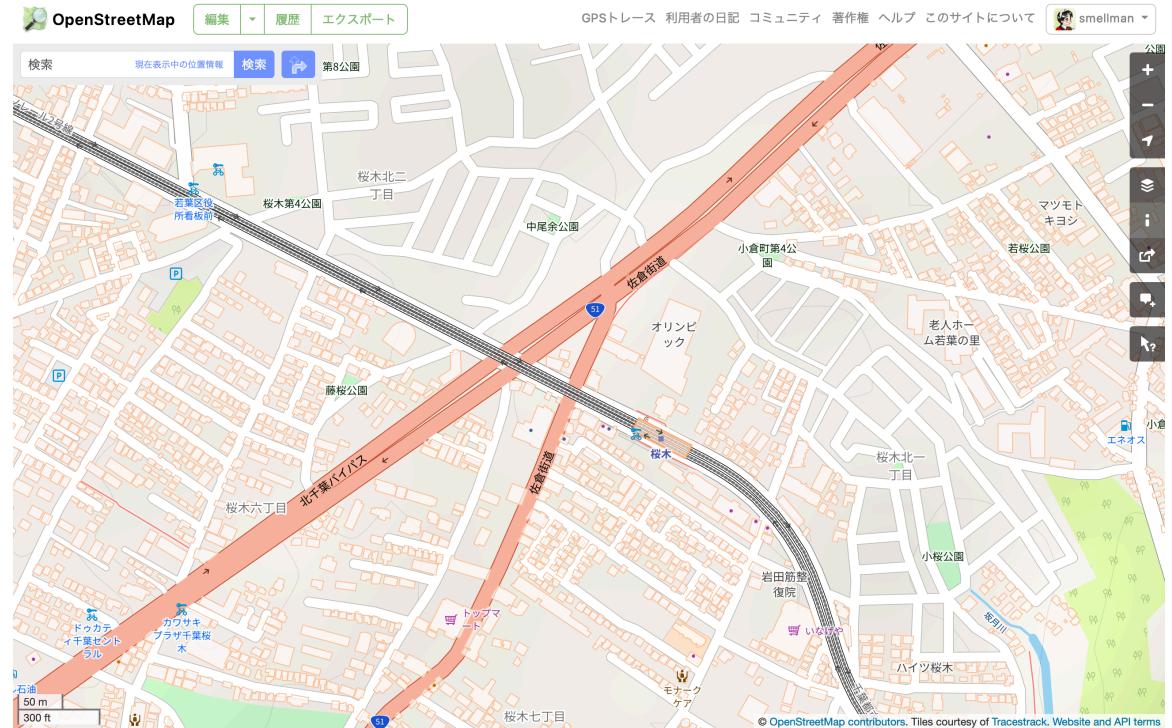


XYZ tile

- De facto standard of tiled map.
 - Web Mercator projection
 - Y coordinate flipped TMS
 - Provide REST API
 - $\{z\}/\{x\}/\{y\}.\{format\}$
 - Anyone provide "Specification"
- Too many libraries support XYZ tile.
 - Leaflet, OpenLayers, Maplibre GL JS, Google Maps API etc.

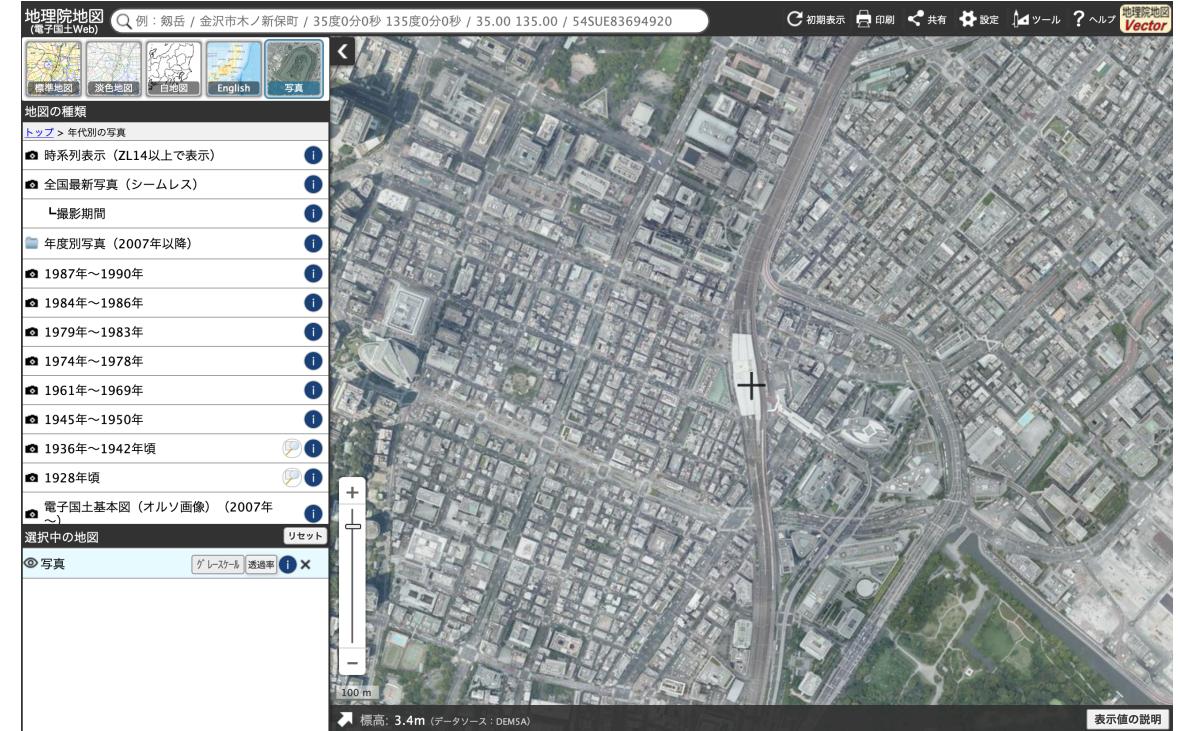
Raster tile (1/3)

- Provides "rendered image"
 - The image doesn't have any "data".
 - Focus to visualization.



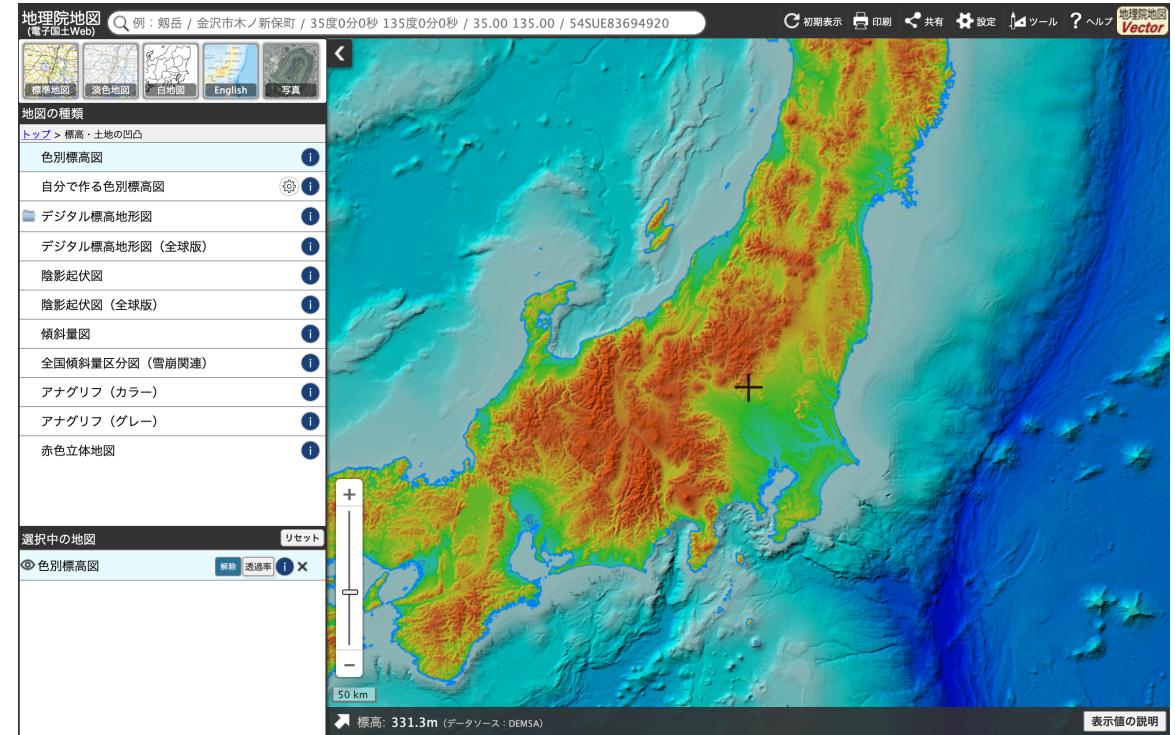
Raster tile (2/3)

- Provides "Satellite images" or "Aerial photograph"
 - Focus to photography.
 - The image doesn't have any "data" too.



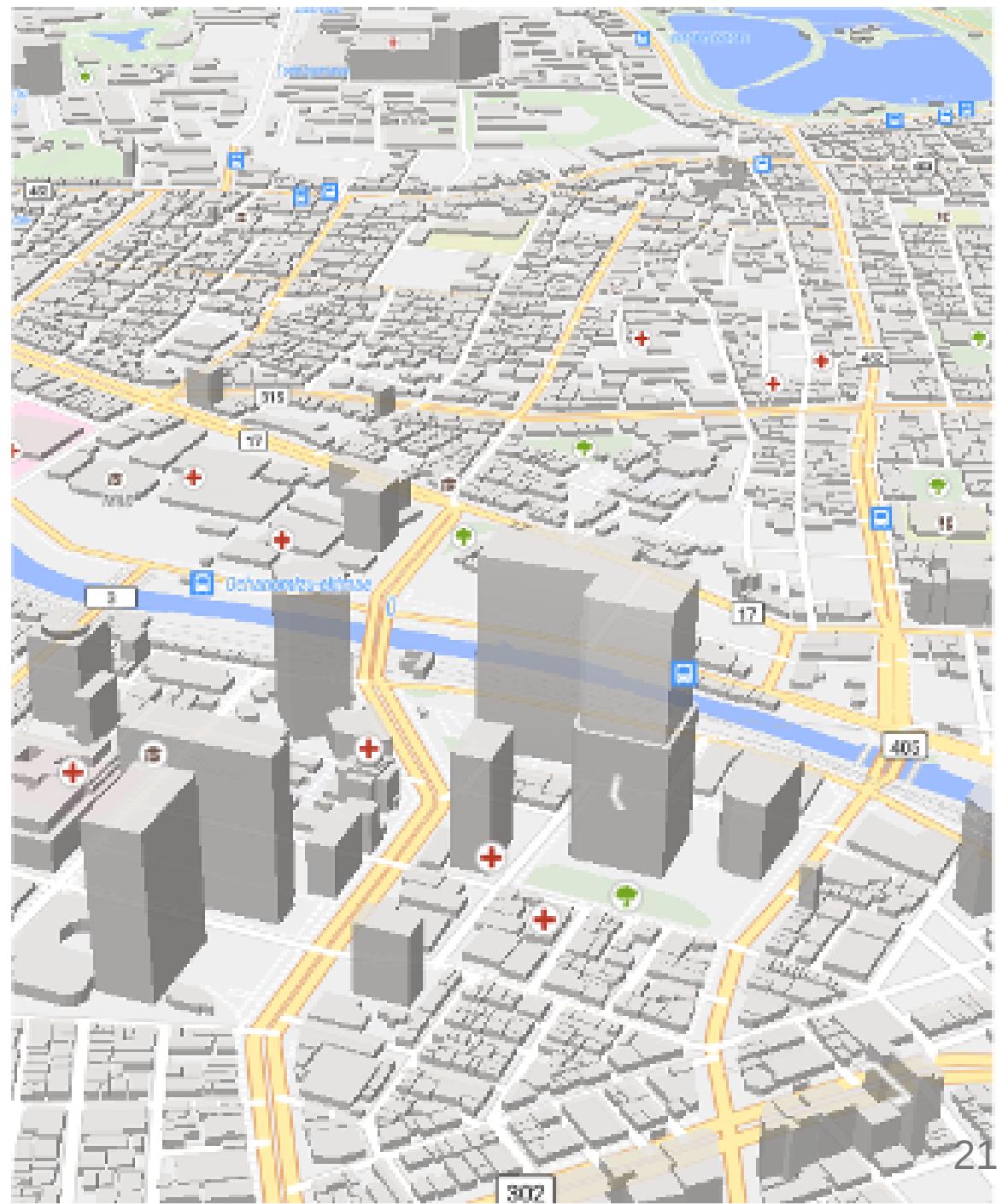
Raster tile (3/3)

- Provides "data" as image.
 - Focus to data.
 - Population, Temperature, Rainfall, Elevation, etc.
 - The image has "data" as color.
 - Sample raster tiles contain the elevation value obtainable by calculating with RGB values.



Vector tile (1/2)

- Provides "Vector data"
 - Each tile contains "Vector data".
 - The tile like a data container.

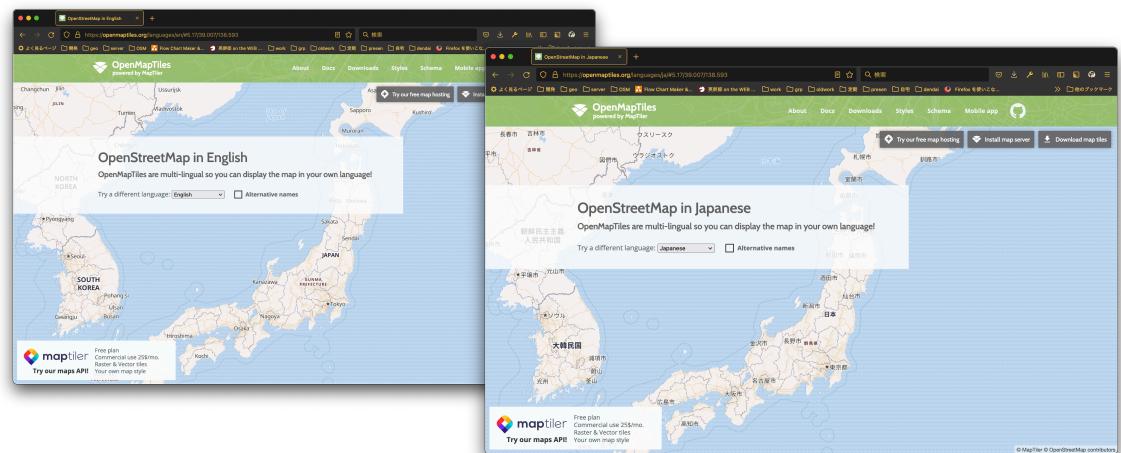


Vector tile (2/2)

- Vector tile doesn't have a style.
 - The client renders images with style settings.
 - Easy to rotation and bearing.
 - Supports 3D rendering.
- Programmable.
 - The client can change the style dynamically.

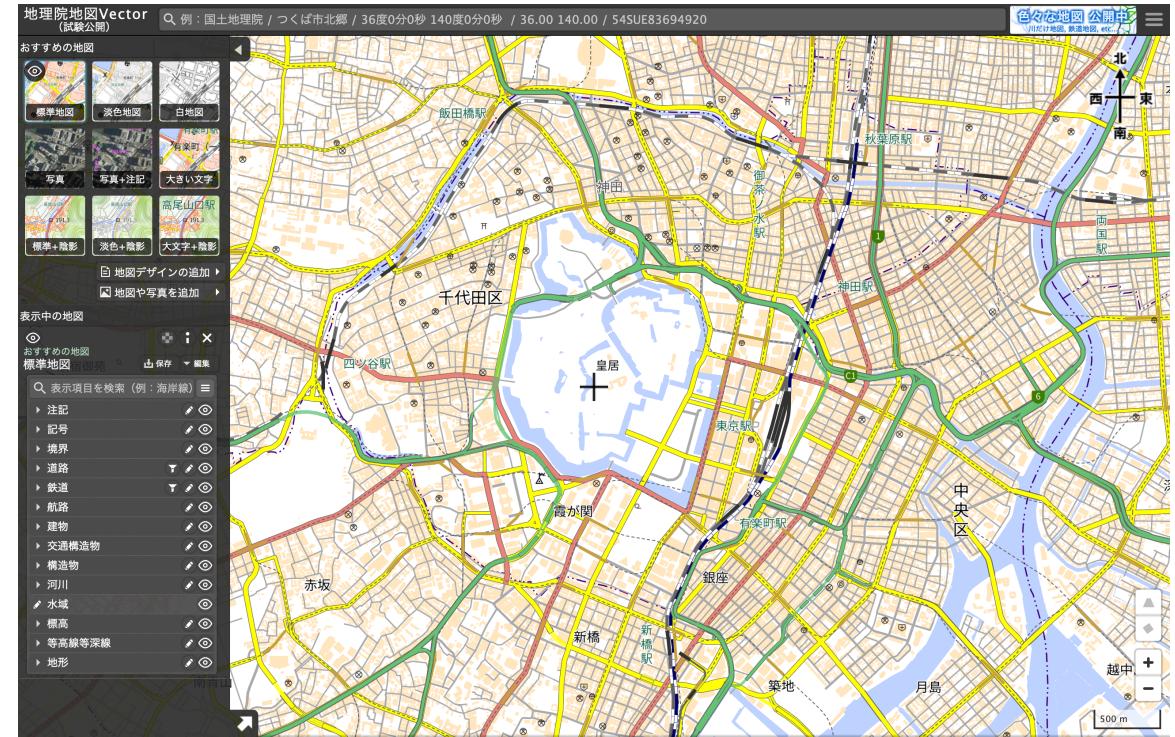
Vector tile example - Multilingual

- <https://openmaptiles.org/languages/>
 - Enable to change main language dynamically.



Vector tile example - Geospatial Information Authority of Japan

- <https://maps.gsi.go.jp/vector/>
 - GSI provides vector tile.
 - Enable to change style dynamically.



Mapbox Vector Tile

- De facto standard of vector tile.
 - Vector tile specification by Mapbox Inc.
- Specification
 - A tile encoded by Protocol Buffer format.
 - Desinged for Web Mercator projection.
 - Supports Layers and Features.

<https://docs.mapbox.com/data/tilesets/guides/vector-tiles-standards/>

Mapbox GL ecosystem and Style Specification

- Mapbox provides Mapbox GL JS(Web), Mapbox GL Native(Smartphone and Desktop application).
 - Mapbox provides specification of styling.
<https://docs.mapbox.com/mapbox-gl-js/style-spec/>



Note: Mapbox GL is proprietary software

- Mapbox GL became proprietary software from end of 2020.
 - Mapbox GL JS is OpenSource software until v1.5.
 - Mapbox GL JS over v2 must require mapbox service's token.
- MapLibre GL ecosystems are fork of mapbox OpenSource versions.
 - <https://maplibre.org/>
 - Highly recommend to use MapLibre GL JS now.

Tile support libraries - Javascript

- Leaflet
 - <https://leafletjs.com/>
 - Lightweight and easy to use.
 - Supports Mapbox Vector Tile with plugin.
- OpenLayers
 - <https://openlayers.org/>
 - Difficult to use but powerful.
 - Supports Mapbox Vector Tile.
- MapLibre GL JS
 - <https://maplibre.org/>

Tile support libraries - Android

- MapLibre GL Native
 - <https://maplibre.org/>
 - Easy to use for Mapbox Vector Tile.
 - Supports raster xyz tile too.
- Google Maps SDK
 - <https://developers.google.com/maps/documentation/android-sdk/overview>
 - Easy to use for raster xyz tile.

Tile support libraries - iOS

- MapLibre GL Native
 - <https://maplibre.org/>
 - Easy to use for Mapbox Vector Tile.
 - Supports raster xyz tile too.
- Mapkit
 - <https://developer.apple.com/documentation/mapkit>
 - Easy to use for raster xyz tile.

Desktop application

- QGIS
 - <https://qgis.org/>
 - Supports raster xyz tile.
 - Supports Mapbox Vector Tile.

Introduction of software and data in this presentation

Requirements

- This presentation requires Linux based OS.
- Also, you can use Raspberry Pi 4.
 - Raspberry Pi 4 is cheap and powerful.
 - Raspberry Pi 4 is ARM64/aarch64 architecture.
 - Raspberry Pi 4 is easy to use for GIS.
- My repository for this presentation supports only ARM64/aarch64 architecture.

Software - GDAL/OGR

- <https://gdal.org/>
- GDAL/OGR is the most popular GIS library and provides command line tools.
 - QGIS based on GDAL/OGR.
- GDAL/OGR supports many GIS data formats.
- GDAL/OGR supports raster xyz tile.

Software - Tippecanoe

- <https://github.com/felt/tippecanoe/>
- Build vector tilesets from large (or small) collections of GeoJSON, FlatGeoBuf or CSV features.
- Tippecanoe is the most popular vector tile builder.

Software - Charites

- Command line tool for writing Mapbox/MapLibre Vector Style Specification in YAML.
 - Organized by The United Nation Vector Tile Toolkit(UNVT).
- Charites convert Style Specification(JSON) to YAML.
 - YAML is easy to read and write for human.
 - YAML is easy to edit for beginners.
- Charites enable to dynamic serving style.

Software - editor

- `nano` is a simple text editor.
 - `nano` is easy to use for both beginners.
- `vim` is a powerful text editor.
 - `vim` is difficult to use for beginners.
 - `vim` is easy to use for experts.

Software - make

- make is a build automation tool.
- make is easy to use for both beginners and experts.
- make is a standard tool of UNIX and Linux.
 - This presentation use make for build and deploy.

Software - nginx

- nginx is a web server.
- nginx is easy to use for both beginners and experts.
- nginx is a standard tool of UNIX and Linux.
 - This presentation use nginx for serving tiles.

Software - tileserver-gl-light

- tileserver-gl-light is a vector tile server.
- useful for inspecting vector tile.

Software - docker

- docker is a container platform.
- docker is easy to use for both beginners and experts.
- This presentation use docker for serving tiles or running tileserver-gl-light.

Data - Global Map

- Digital geographic information
 - Provided by International Steering Committee for Global Mapping(ISCGM).
 - Composed of 8 Data Sets
 - Vector Data (Transportation, Boundaries, Darainage, Population Centre)
 - Raster Data (Elevation, Vegetation, Land Cover, Land Use)
- Free for non-commercial use.

Global Map - archive

- Archives and website were moved into github by GSI.
 - <https://github.com/globalmaps>
 - <https://globalmaps.github.io/>
- Old website was closed
- Some countries provides global map archives at the national site.
 - All links:
<https://github.com/globalmaps/projectmanagement/blob/master/REPOS.md>
- Some links are dead now.

Global map – format

- Vector data provide as Shapefile.
 - It provided as Geography Markup Language (GML) format.
- Raster data provide as GeoTiff file.
 - It provided as Band interleaved by line (BIL) format.

Data – Aerial photograph

- <https://www.mlit.go.jp/plateau/>
- In Japan, Plateau Project release too many Aerial photograph data.
 - Plateau released PointCloud, 3D data, and Aerial photograph.
 - Aerial photograph is released as GeoTiff data.
 - It is good sample to create raster tile.

Data - OpenStreetMap

- <https://www.openstreetmap.org/>
- OpenStreetMap is the most popular OpenData.
 - OpenStreetMap provides planet data as PBF format.
- Today's presentation use OpenStreetMap data as sample data.
 - Use small area data for easy to understand.

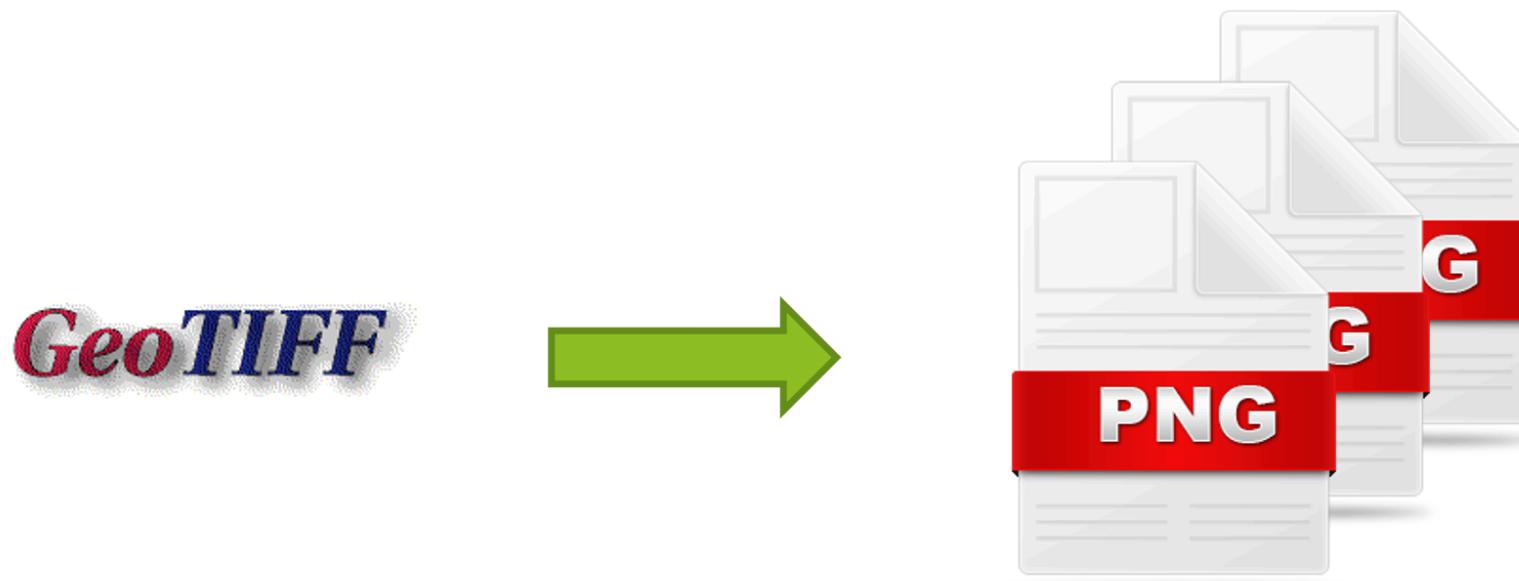
Data for this presentation

- Global Map Sri Lanka 1.0
 - <https://github.com/globalmaps/gmlk10>
- Global Map Sri Lanka 2.0
 - <https://github.com/globalmaps/gmlk20>
- Plateau Higashimurayama City in Tokyo GeoTIFF
 - <https://www.geospatial.jp/ckan/dataset/plateau-13213-higashimurayama-shi-2020>
- OpenStreetMap data
 - <https://tile.openstreetmap.jp/static/planet.pmtiles>

How to create your own tiled map

Raster tile processing pattern 1: Global map (One GeoTIFF file)

- Download GeoTIFF file from Global Map archive.
- Enable transparency.
- Convert GeoTIFF to XYZ tile using gdal2tiles.



How to process

```
cd ~/jica_scripts/raster_tile_gm  
make fetch # Download GeoTIFF file from Global Map archive.  
make transparent # Enable transparency.  
make generate_tile # Convert GeoTIFF to XYZ tile using gdal2tiles.  
make serve # run nginx
```

How to read Makefile

fetch:

```
git clone https://github.com/globalmaps/gmlk10.git
```

transparent:

```
gdalbuildvrt -srcnodata "0 0 99" el.vrt gmlk10/el.tif
```

generate_tile:

```
gdal_translate -of vrt -expand rgba el.vrt temp.vrt  
gdal2tiles.py --xyz -s EPSG:4326 -z 0-11 temp.vrt
```

serve:

```
serve -p 8000 temp/
```

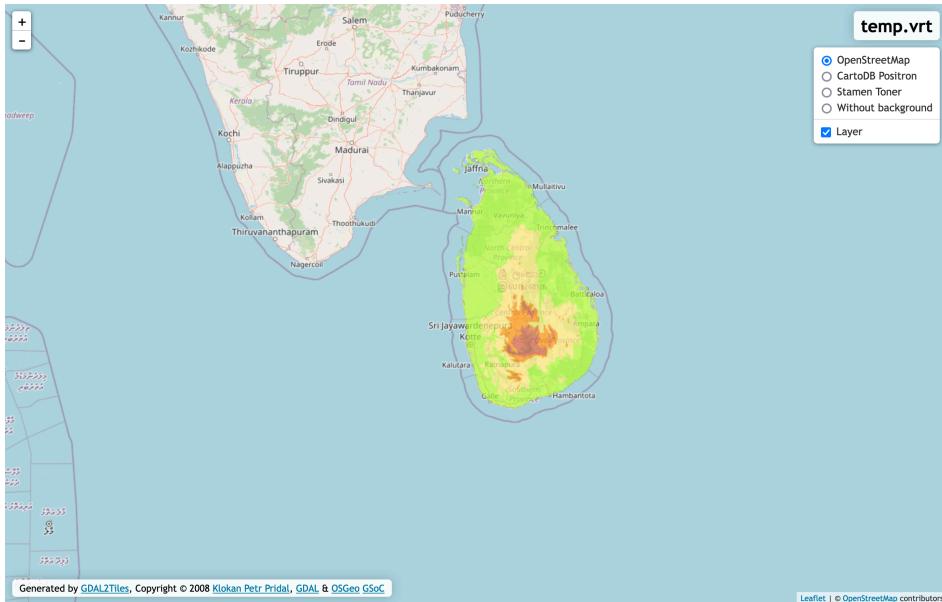
Makefile is simple to run tasks.

task_name:

command

Result

Access to <http://<your host>.local:8000/leaflet.html>



Raster tile processing pattern 2: Plateau (Many GeoTIFF files)

- Generate VRT file from GeoTIFF files.
- Convert VRT file to XYZ tile using gdal2tiles.

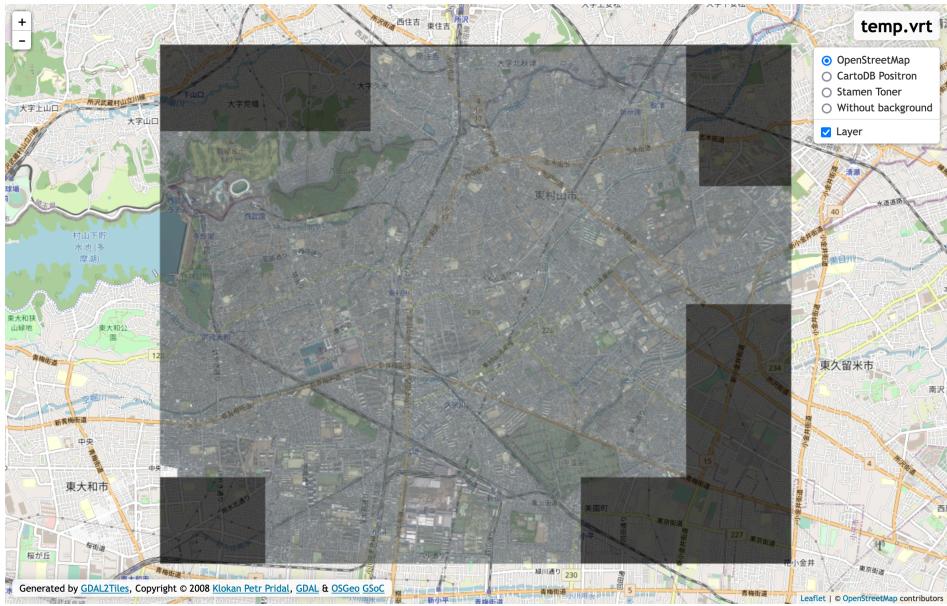


How to process

```
cd ~/jica_scripts/raster_tile_plateau  
make fetch # Download GeoTIFF file from Plateau archive and unarchive  
make buildvrt # Generate VRT file from GeoTIFF files.  
make generate_tile # Convert VRT file to XYZ tile using gdal2tiles.  
make serve # run serve
```

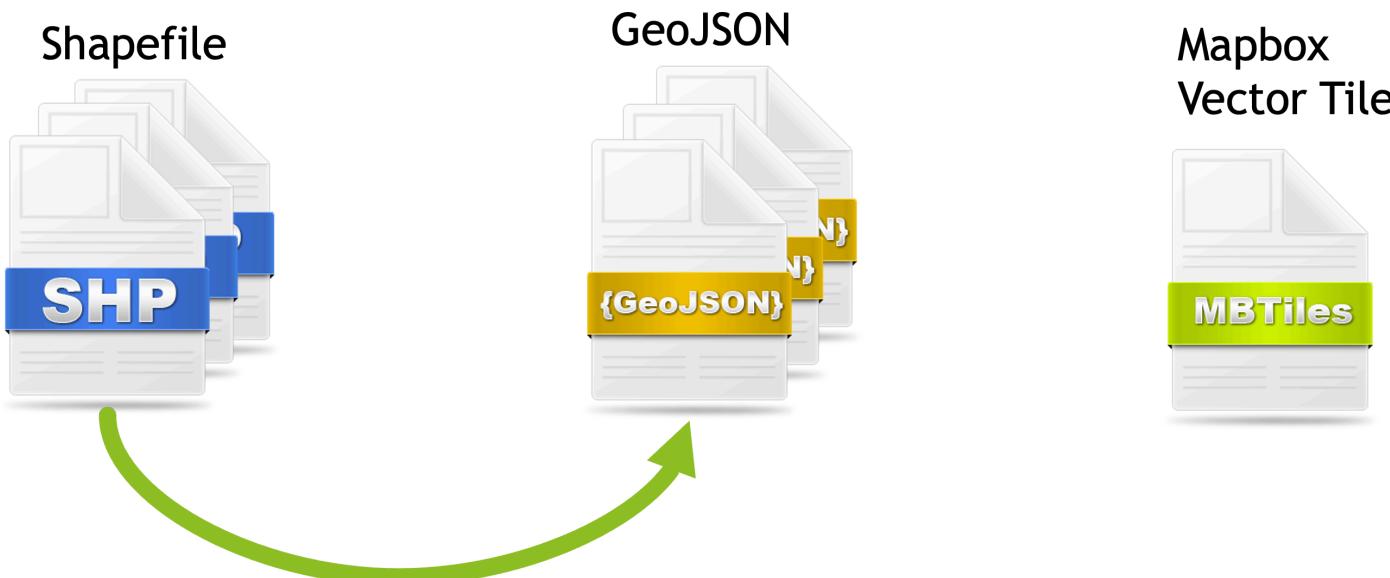
Result

Access to <http://<your host>.local:8000/leaflet.html>



Vector tile processing pattern: Global map

- Download Shapefile file from Global Map archive.
- Convert Shapefile to GeoJSON using ogr2ogr.
- Convert GeoJSON to Mapbox Vector Tile using tippecanoe.

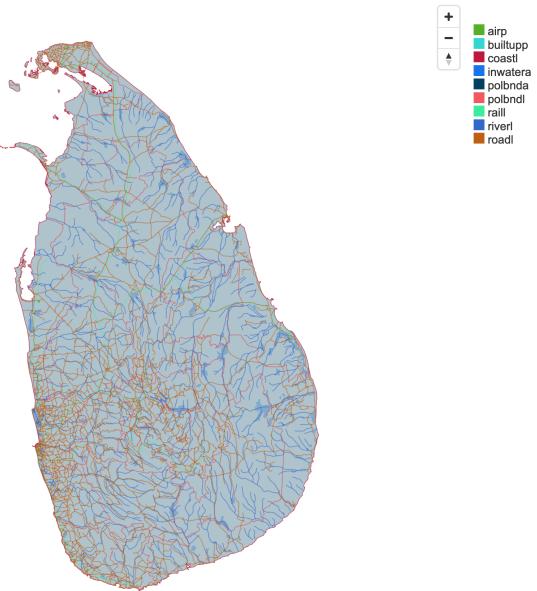


How to process

```
make fetch # Download Shapefile file from Global Map archive.  
make convert # Convert Shapefile to GeoJSON using ogr2ogr.  
make generate # Convert GeoJSON to Mapbox Vector Tile using tippecanoe.  
make tileserver-gl # run tileserver-gl-light
```

Result

Access to <http://<your host>.local:8081/>



Makefile (1/3)

fetch:

```
git clone https://github.com/globalmaps/gmlk20.git
```

convert:

```
cd gmlk20; \
ogr2ogr airp_lka.geojson -s_srs EPSG:4326 -t_srs EPSG:4326 airp_lka.shp; \
ogr2ogr builtupp_lka.geojson -s_srs EPSG:4326 -t_srs EPSG:4326 builtupp_lka.shp; \
ogr2ogr coastl_lka.geojson -s_srs EPSG:4326 -t_srs EPSG:4326 coastl_lka.shp; \
ogr2ogr inwatera_lka.geojson -s_srs EPSG:4326 -t_srs EPSG:4326 inwatera_lka.shp; \
ogr2ogr polbnda_lka.geojson -s_srs EPSG:4326 -t_srs EPSG:4326 polbnda_lka.shp; \
ogr2ogr polbndl_lka.geojson -s_srs EPSG:4326 -t_srs EPSG:4326 polbndl_lka.shp; \
ogr2ogr raill_lka.geojson -s_srs EPSG:4326 -t_srs EPSG:4326 raill_lka.shp; \
ogr2ogr riverl_lka.geojson -s_srs EPSG:4326 -t_srs EPSG:4326 riverl_lka.shp; \
ogr2ogr roadl_lka.geojson -s_srs EPSG:4326 -t_srs EPSG:4326 roadl_lka.shp
```

9 outputs

- ogr2ogr convert Shapefile to GeoJSON.
 - Notes: Those Shapefiles are not included .prj file.

Makefile (2/3)

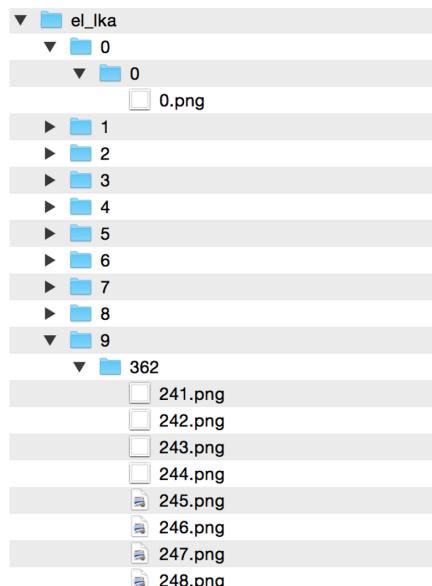
```
generate:
    tippecanoe -o lka.pmtiles \
        -L airp:gmlk20/airp_lka.geojson \
        -L builtupp:gmlk20/builtupp_lka.geojson \
        -L coastl:gmlk20/coastl_lka.geojson \
        -L inwaterna:gmlk20/inwaterna_lka.geojson \
        -L polbnda:gmlk20/polbnda_lka.geojson \
        -L polbndl:gmlk20/polbndl_lka.geojson \
        -L raill:gmlk20/raill_lka.geojson \
        -L riverl:gmlk20/riverl_lka.geojson \
        -L roadl:gmlk20/roadl_lka.geojson
    tippecanoe -o lka.mbtiles \
        -L airp:gmlk20/airp_lka.geojson \
        -L builtupp:gmlk20/builtupp_lka.geojson \
        -L coastl:gmlk20/coastl_lka.geojson \
        -L inwaterna:gmlk20/inwaterna_lka.geojson \
        -L polbnda:gmlk20/polbnda_lka.geojson \
        -L polbndl:gmlk20/polbndl_lka.geojson \
        -L raill:gmlk20/raill_lka.geojson \
        -L riverl:gmlk20/riverl_lka.geojson \
        -L roadl:gmlk20/roadl_lka.geojson
```

2 outputs

- tippecanoe runs 2 times and generate 2 outputs.
 - .mbtiles file
 - SQLite database file.
 - Contains vector tile.
 - .pmtiles file
 - "Cloud Native" format.
 - You can host .pmtiles as static file.

MBTiles - SQLite database

- MBTiles is container of tile.
 - MBTiles is single file database(SQLite).
 - TMS schema.



X	Y	Z	blob
0	0	0	(binary)
...
241	362	9	(binary)

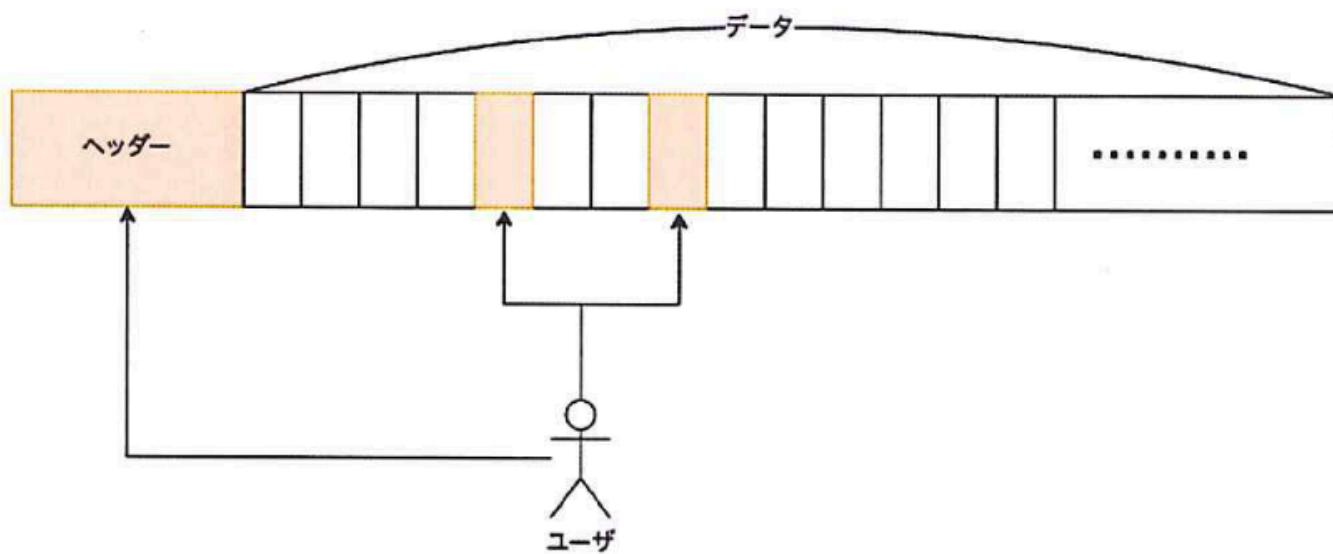
Makefile (3/3)

```
tileserver-gl:
```

```
    tileserver-gl-light --port 8000 --bind 0.0.0.0 --file lka.mbtiles
```

PMTiles - Cloud Native format

- PMTiles is similar to MBTiles.
 - "Cloud Native" format.
 - You can easily convert mbtiles to pmtiles using `pmtiles` command.



How to design your own tiled map

Design tiled map

- Vector tile doesn't have a style.
 - The client renders images with style settings.
- In this presentation, we use `charites` to design tiled map.
 - Charites convert Style Specification(JSON) to YAML.
 - YAML is easy to read and write for human.
 - YAML is easy to edit for beginners.

Try to edit style

```
cd ~/jica_scripts/vector_tile  
make practice
```

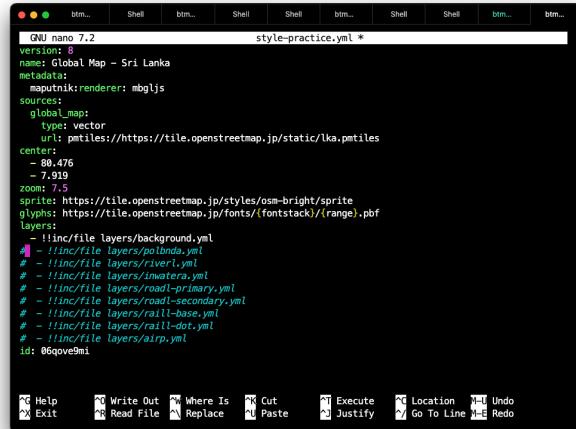
Open <http://<your host>.local:8000/> in your browser.

Open other terminal and run following command.

```
cd ~/jica_scripts/vector_tile  
nano style-practice.yml
```

nano

- nano is a simple text editor.
 - nano is easy to use for beginer.
- Ctrl + O: Save file
- Ctrl + X: Exit nano



The screenshot shows the nano text editor window with the following content:

```
GNU nano 7.2 style-practice.yml *
version: 8
name: Global Map - Sri Lanka
metadata:
  mbgljs: renderer: mbgljs
sources:
  global_map:
    type: vector
    url: ptiles://https://tile.openstreetmap.jp/static/lka.ptiles
center:
  - 80.476
  - 7.919
zoom: 9
sprite: https://tile.openstreetmap.jp/styles/osm-bright/sprite
glyphs: https://tile.openstreetmap.jp/fonts/(fontstack)/(range).pbf
layers:
  - !!inc/file layers/background.yaml
# - !!inc/file layers/polylines.yaml
# - !!inc/file layers/river.yaml
# - !!inc/file layers/water.yaml
# - !!inc/file layers/road-primary.yaml
# - !!inc/file layers/road-secondary.yaml
# - !!inc/file layers/rail-primary.yaml
# - !!inc/file layers/rail-dot.yaml
# - !!inc/file layers/airports.yaml
id: 06qovve9mi
```

The bottom of the window shows the standard nano command bar with icons for Help, Write Out, Where Is, Cut, Paste, Execute, Justify, Location, Go To Line, Undo, Redo, Exit, Read File, Replace, and Insert.

Remove comments on layers

Remove comments in style-practice.yml.

```
layers:  
  - !!inc/file layers/background.yml  
#  - !!inc/file layers/polbnda.yml  
#  - !!inc/file layers/riverl.yml  
#  - !!inc/file layers/inwatera.yml  
#  - !!inc/file layers/roadl-primary.yml  
#  - !!inc/file layers/roadl-secondary.yml  
#  - !!inc/file layers/raill-base.yml  
#  - !!inc/file layers/raill-dot.yml  
#  - !!inc/file layers/airp.yml
```

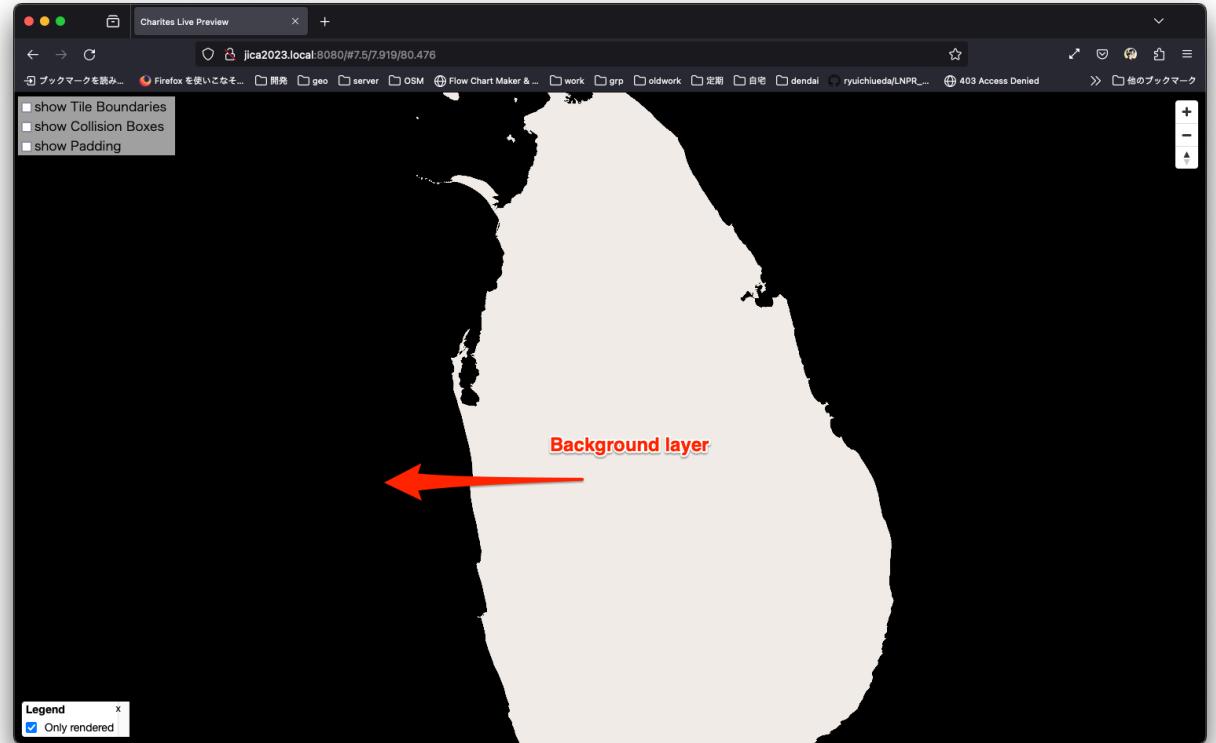
Layers in Maplibre Style Specification

- Background
- Fill
- Line
- Symbol
- Circle
- Raster
- Hillshade
- Fill Extrusion
 - It used for 3D rendering.

<https://maplibre.org/maplibre-style-spec/>

Background layer

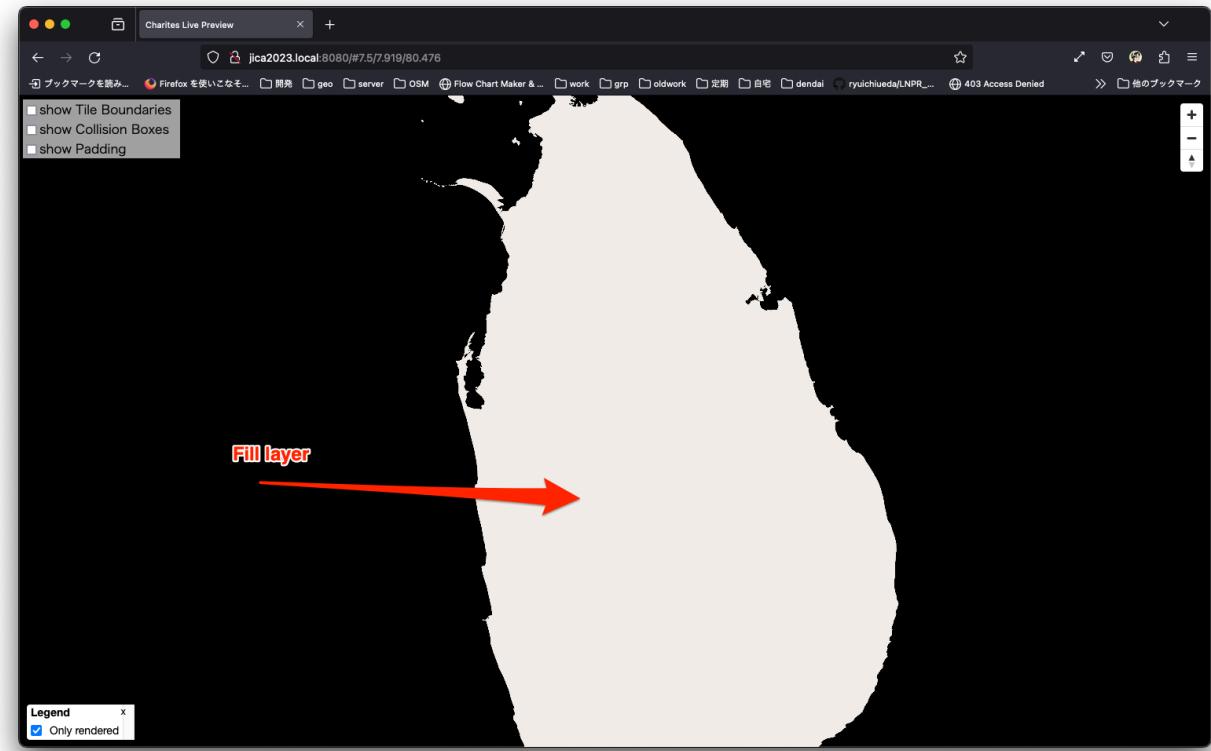
```
id: background
type: background
paint:
  background-color: rgb(0,0,0)
```



Fill layer

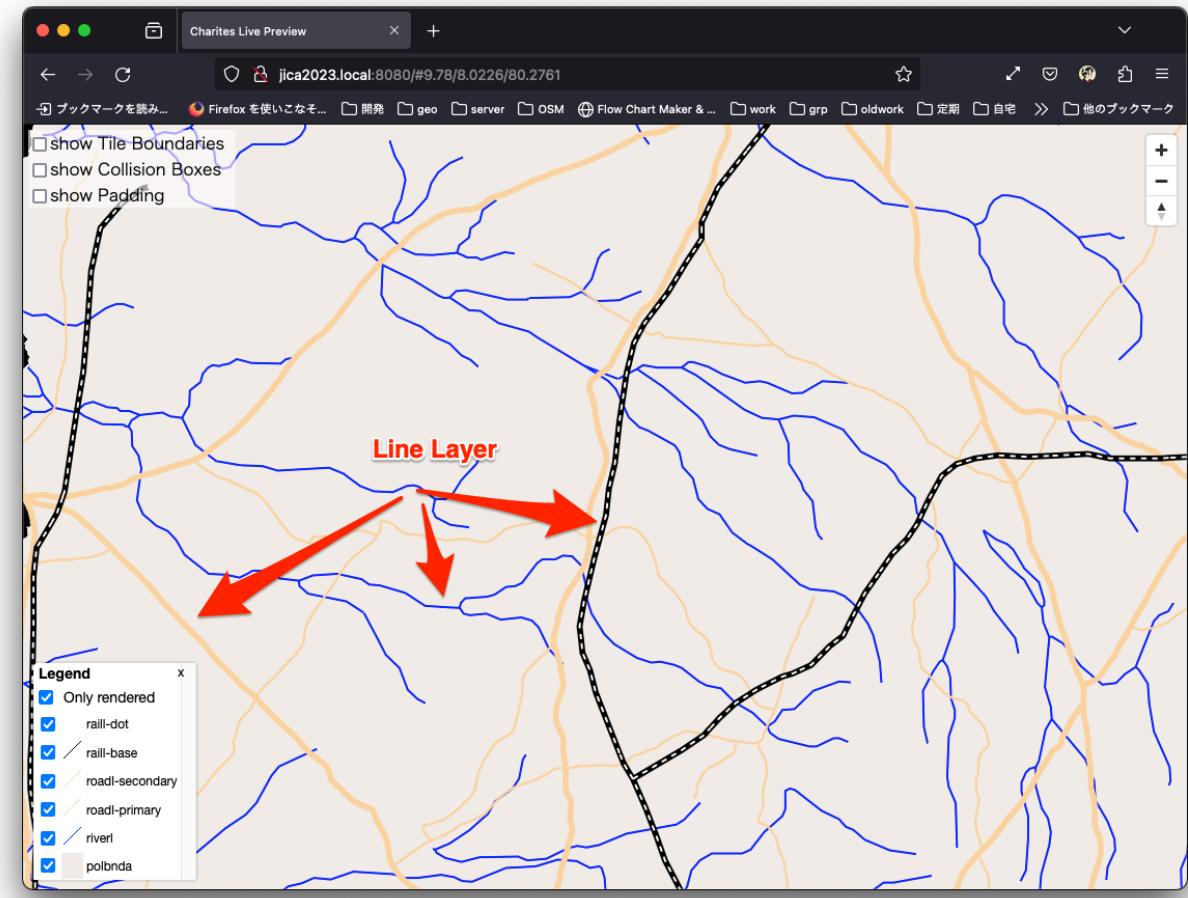
```
id: polbnda
type: fill
source: global_map
source-layer: polbnda
paint:
  fill-color: '#f2efe9'
```

- source: global_map means "global_map" source in sources section.
- source-layer: polbnda means "polbnda" layer in global_map source.



Line layer

```
id: riverl
type: line
source: global_map
source-layer: riverl
paint:
  line-color: rgb(0,0,255)
  line-width:
    base: 1
    stops:
      - - 6
      - - 0.5
      - - 10
      - - 2
```



Line layer

- Draw line with polyline features.
 - Normal line.
 - Dash-array line.
 - Following example is Normal line + Dash-array line.



Filter

roadl-primary.yml and roadl-secondary.yml use filter.

roadl-primary.yml use following filter.

```
filter:  
  - all  
  - - '=='  
  - rtt  
  - '14'
```

'rtt' is a field name in roadl layer and '14' is primary route.

Zoom function

- Zoom function is useful to change style dynamically.
 - Set Zoom 6 to 1 and Zoom 10 to 6, the value will increase between Zoom 6 and 10.
- "base" property will use to control the rate which the function output increases.
 - "base = 1" will be increased linearly.

<https://maplibre.org/maplibre-style-spec/expressions/>

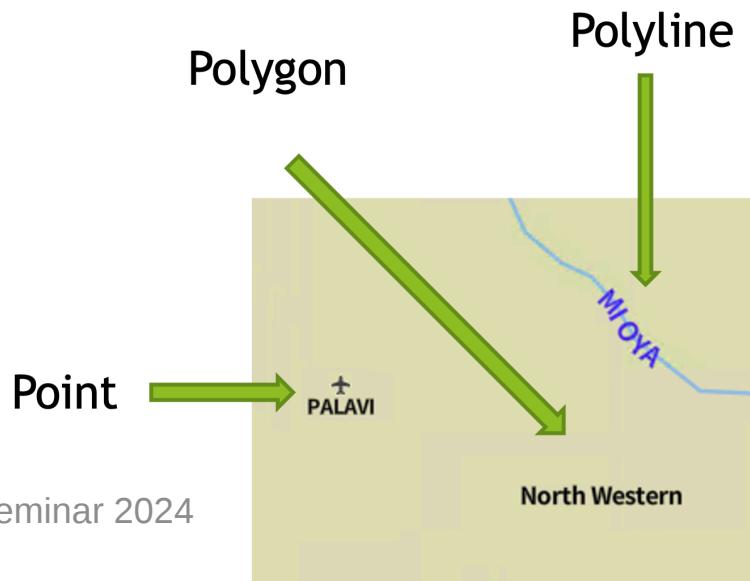
Symbol layer

```
id: airp
type: symbol
source: global_map
source-layer: airp
layout:
  icon-image: airport_11
  text-field: '{nam}'
  text-offset:
    - 0
    - 0.6
```



Symbol layer

- Draw symbol with point features.
 - Icon
 - Text
 - Text with icon
- Allow Point, Polygon and Polyline features.



icon-image and text-field

- icon-image is a property of symbol layer.
 - icon-image is a name of icon.
 - icon-image is defined in sprite.
- text-field is a property of symbol layer.
 - text-field is a name of field in source data.
 - It can use Feature Properties using {field_name}.

text-offset

- text-offset is a property of symbol layer.
 - text-offset is a offset of text.
 - It can use array of [x, y].
 - x and y are offset from center of point.

```
layout:  
  icon-image: airport_11  
  text-field: '{nam}'  
  text-offset:  
    - 0  
    - 0.6
```

Convert your style via charites

Stop `make practice` command and run following command.

```
make build
```

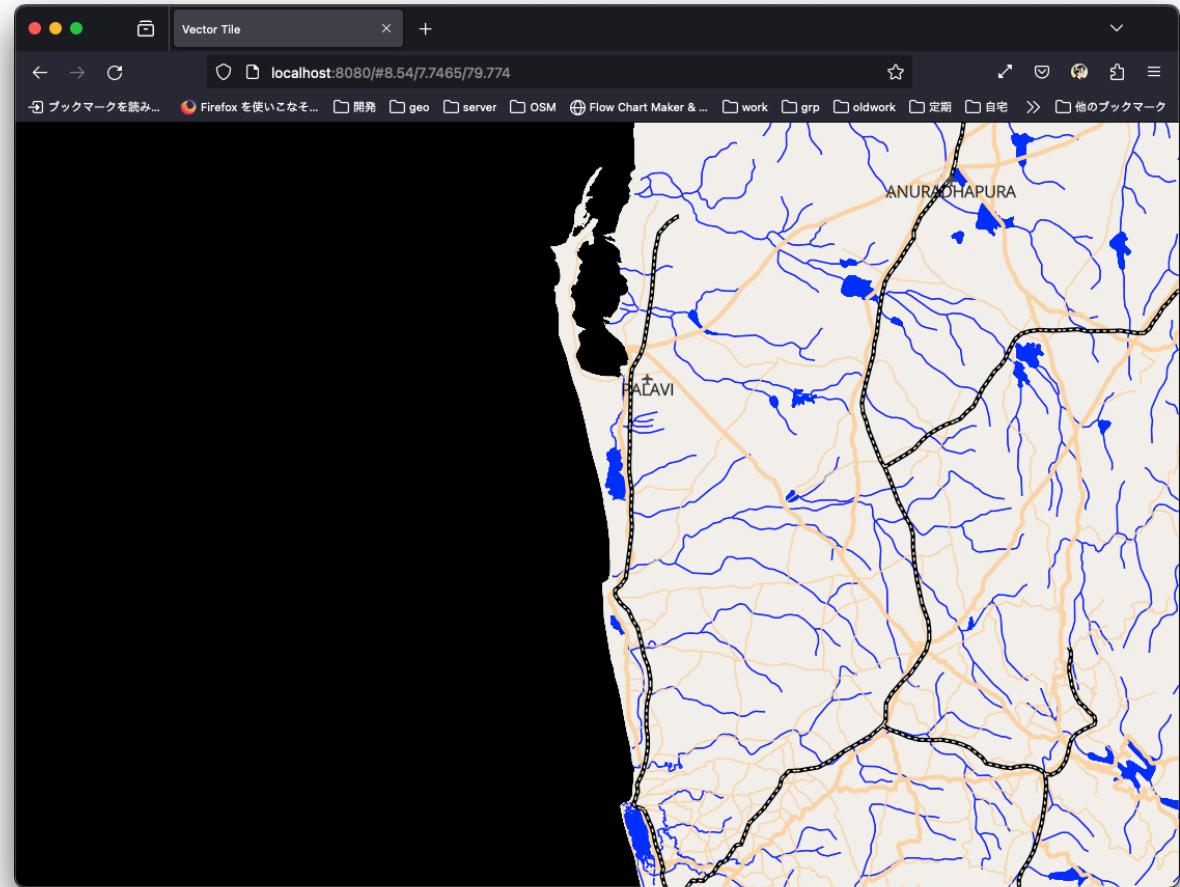
`Makefile` is simple to run tasks.

```
build:
charites convert style-practice.yml style-practice.json
```

Result

make serve

Open <http://<your host>.local:8000/>
in your browser.



How to distribute your own tiled map

Raster tile hosting (1)

- If you use small number of data only, hosting as static image is easy.
 - Use nginx or Apache HTTP Server.
 - Use AWS S3 or Google Cloud Storage.
 - Github Pages is good for small data and free.
 - Be careful to license of tile images.

<https://docs.github.com/en/pages/getting-started-with-github-pages/about-github-pages>

Raster tile hosting (2)

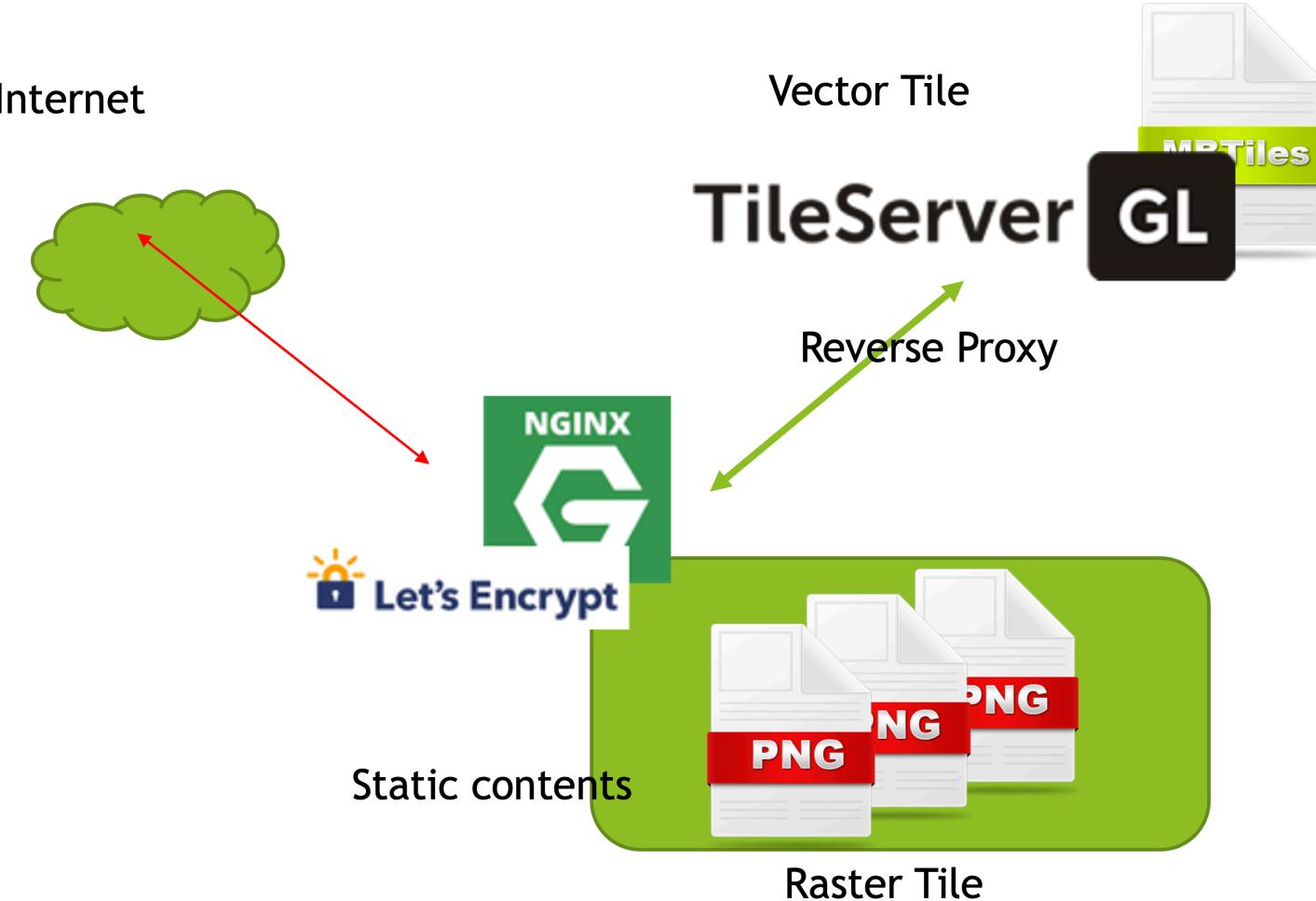
- If you use large number of data, be careful to hosting.
 - File system limitation: max number of files.
 - Ext4 on Linux: 4,294,967,295 files(specified at filesystem creation time)
 - File copy will take a long time.
 - MBTiles is a solution to hosting large number of data.
 - MBUtil is useful to create .mbtiles from tile images.

```
mb-util temp/ e1.mbtiles
```

Vector tile hosting - tileserver-gl

- Tileservice GL is useful.
 - But vector tiles needs SSL access in internet.
 - Let's encrypt is useful to get SSL certificate.
 - <https://letsencrypt.org/>
 - Setup frontend server(Apache/nginx/etc) and connect from server with reverse proxy.

Overview - nginx



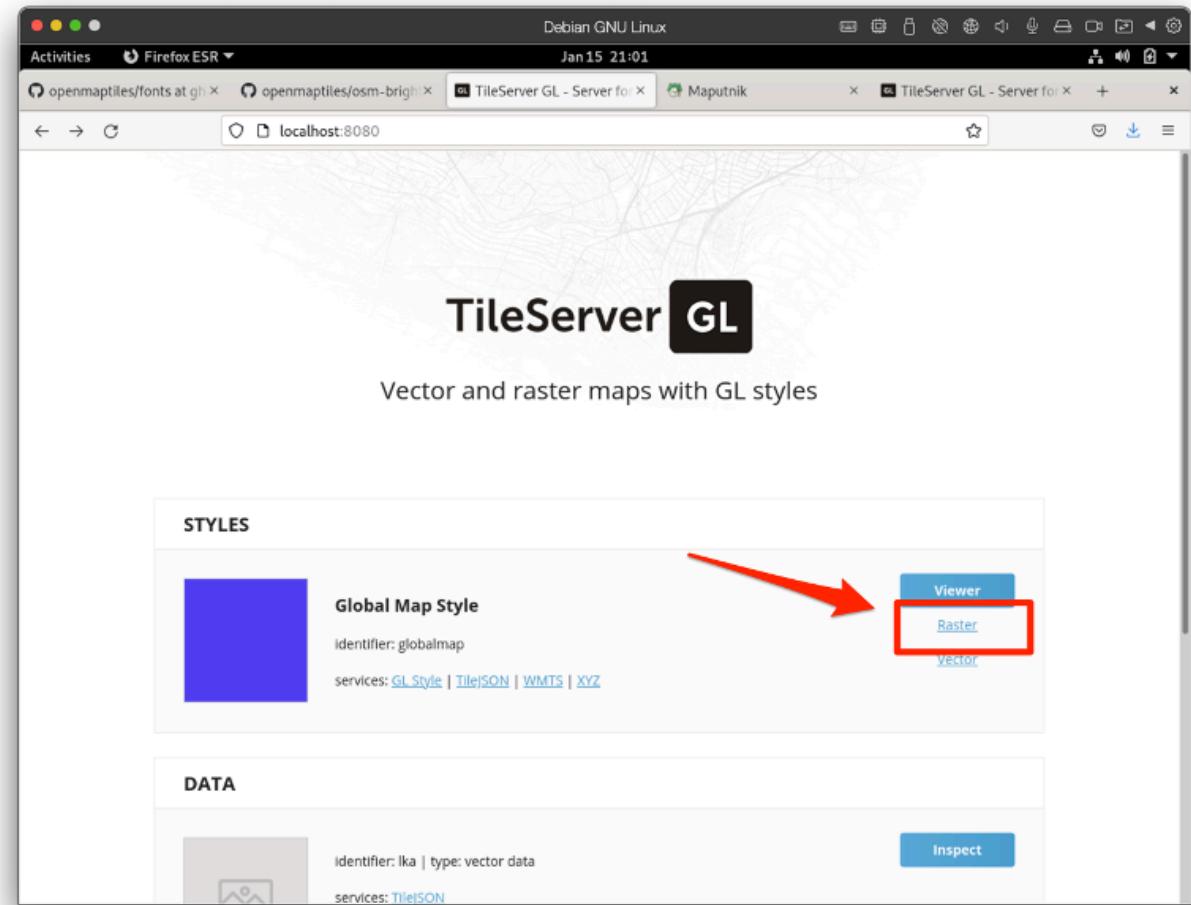
Reverse proxy setting

- Nginx is easy to setup reverse proxy.

```
location / {  
    proxy_set_header X-Forwarded-Proto https;  
    proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;  
    proxy_set_header Host $http_host;  
    proxy_pass http://localhost:8080;  
}
```

Server-side rendering

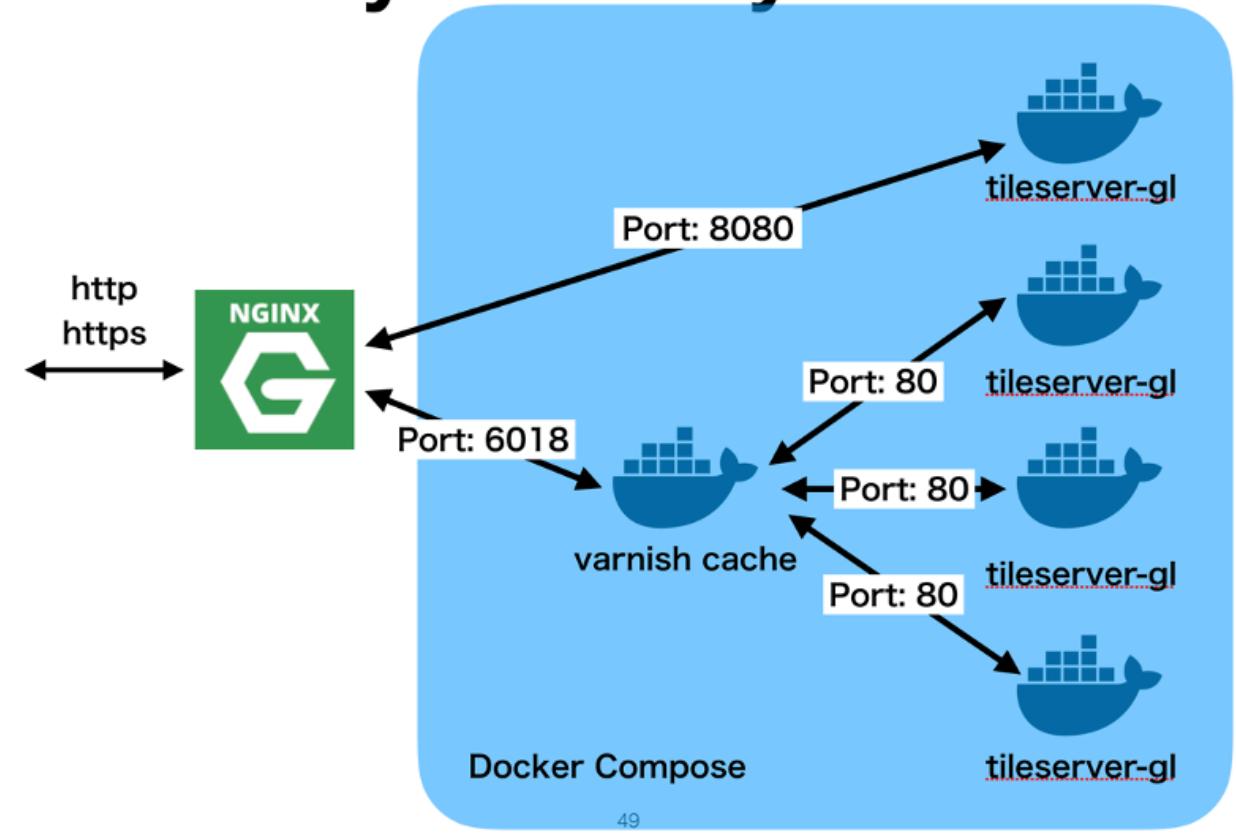
- Tileserver GL can deliver raster tile if you host style.
 - But rendering is slow.
 - If you use this function, you should use cache server.



Tileserver GL - cache

- Use varnish cache for raster rendering.
 - <https://varnish-cache.org/>
- <https://tile.openstreetmap.jp/> use varnish cache.
 - 20 processes run.
 - 20Core CPU and 64GB RAM.

system layout



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Vector tile hosting - pmtiles

- PMTiles is useful to hosting vector tile.
 - PMTiles is "Cloud Native" format.
 - PMTiles is easy to host as static file.
 - Nginx / Apache / AWS S3 / Google Cloud Storage etc.

<https://github.com/protomaps/PMTiles>

PMTiles nginx setting - CORS setting

```
add_header 'Access-Control-Allow-Origin' "$http_origin" always;
add_header 'Access-Control-Allow-Credentials' 'true' always;
add_header 'Access-Control-Allow-Methods' 'GET, POST, PUT, DELETE, OPTIONS' always;
add_header 'Access-Control-Allow-Headers' 'Accept,Authorization,Cache-Control,Content-Type,DNT,If-Modified-Since,Keep-Alive,Origin,Range,User-Agent,X-Requested-With' always;

if ($request_method = 'OPTIONS') {
    # Tell client that this pre-flight info is valid for 20 days
    add_header 'Access-Control-Allow-Origin' "$http_origin" always;
    add_header 'Access-Control-Allow-Headers' 'Accept,Authorization,Cache-Control,Content-Type,DNT,If-Modified-Since,Keep-Alive,Origin,Range,User-Agent,X-Requested-With' always;
    add_header 'Access-Control-Max-Age' 1728000;
    add_header 'Content-Type' 'text/plain charset=UTF-8';
    add_header 'Content-Length' 0;
    return 204;
}
```

see: <https://github.com/smellman/pmtiles-example>

Static hosting usecase - IPFS

- IPFS is a peer-to-peer hypermedia protocol.
 - <https://ipfs.tech/>
- IPFS is useful to hosting static files.
 - IPFS is useful to hosting PMTiles.

IPFS - How to start daemon

```
cd ~/jica_scripts/system  
make ipfs-init  
make ipfs-daemon
```

IPFS - How to add file

```
cd ~/jica_scripts/vector_tile  
make ipfs
```

Output `CID` is IPFS Content Identifier.

```
added QmRSsj5FstJt8Rvrvp4GKG4i77yRredn8eHAuYoNkKhWpW 1ka.pmtiles
```

IPFS - How to access

Copy CID, then.

```
nano style-ipfs.yml
```

Paste CID to `sources` section.

```
sources:  
  global_map:  
    type: vector  
    url: >-  
      pmTiles://https://smb.optgeo.org/ipfs/<Your CID>
```

<https://smb.optgeo.org/ipfs/> is IPFS gateway server running by Hidenori Fujimura.

IPFS - How to access

```
cd ~/jica_scripts/vector_tile  
make build-ipfs  
make serve
```

Open <http://<your host>.local:8000/index-ipfs.html> in your browser.

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