

AN INTRODUCTION TO GOOGLE'S S2 GEOMETRY LIBRARY

HAVING FUN WITH GEOGRAPHIC DATA IN YOUR SOFTWARE

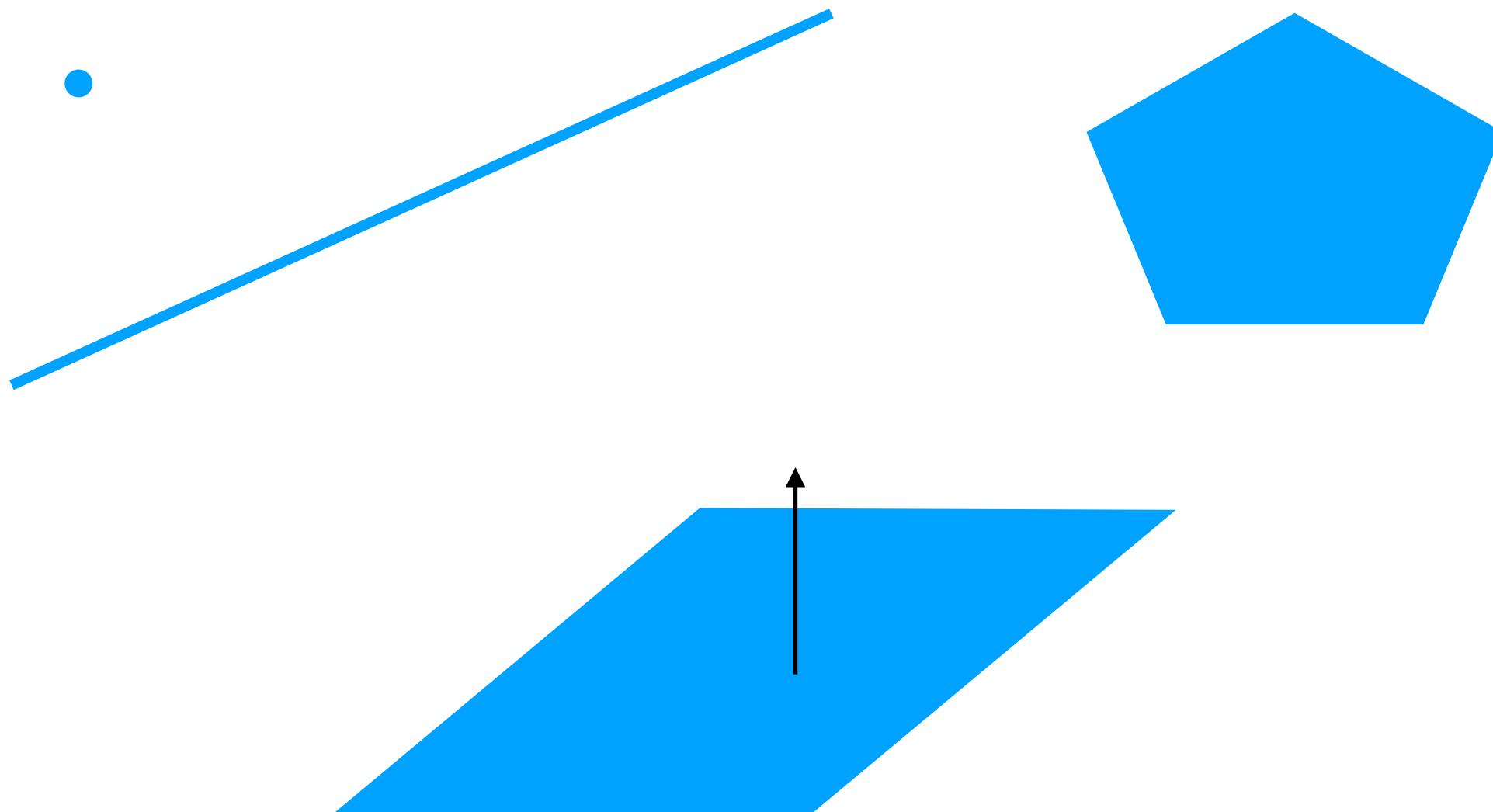
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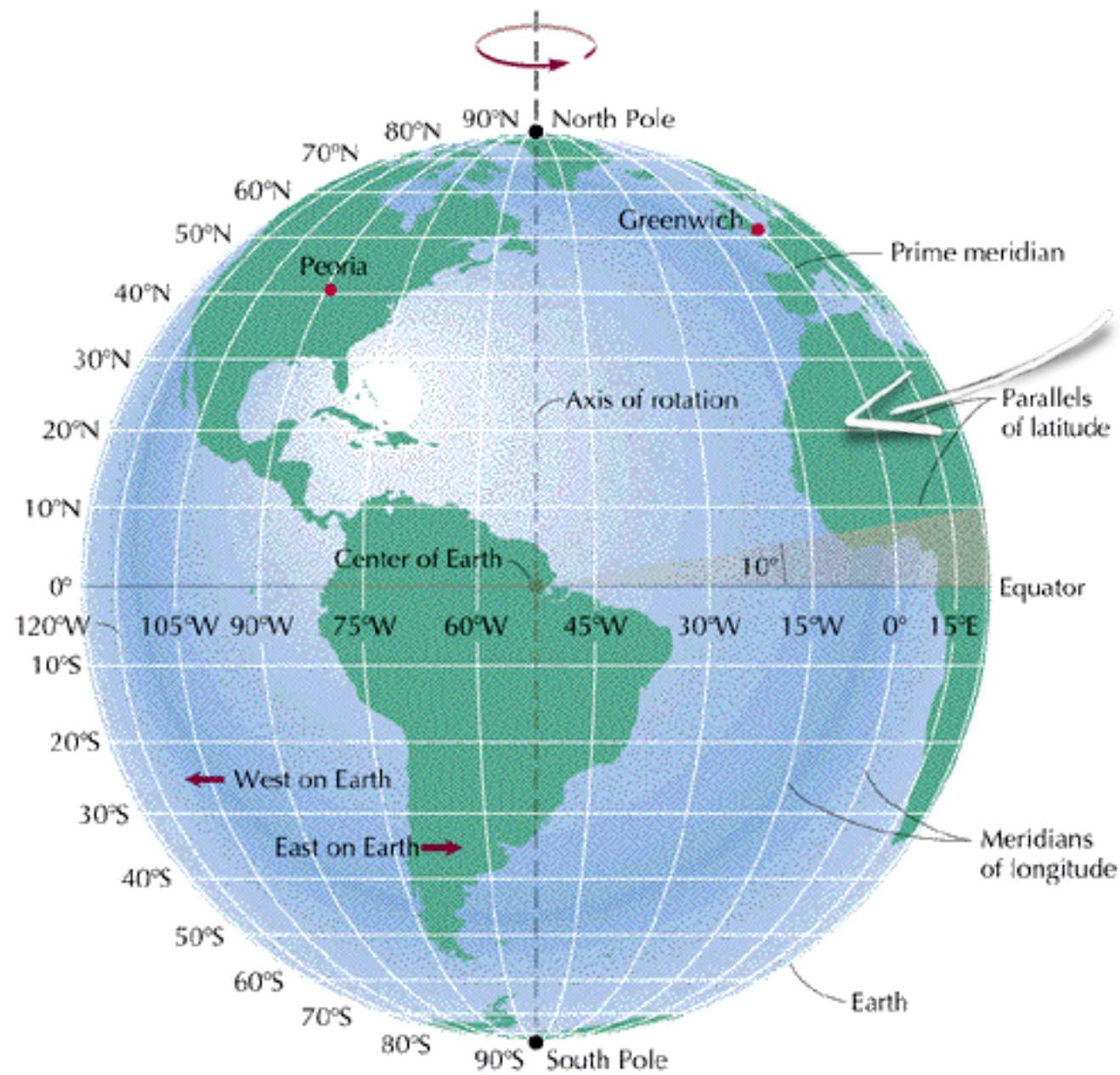
phpers
SUMMIT
2017



DANE GEOPRZESTZENNE

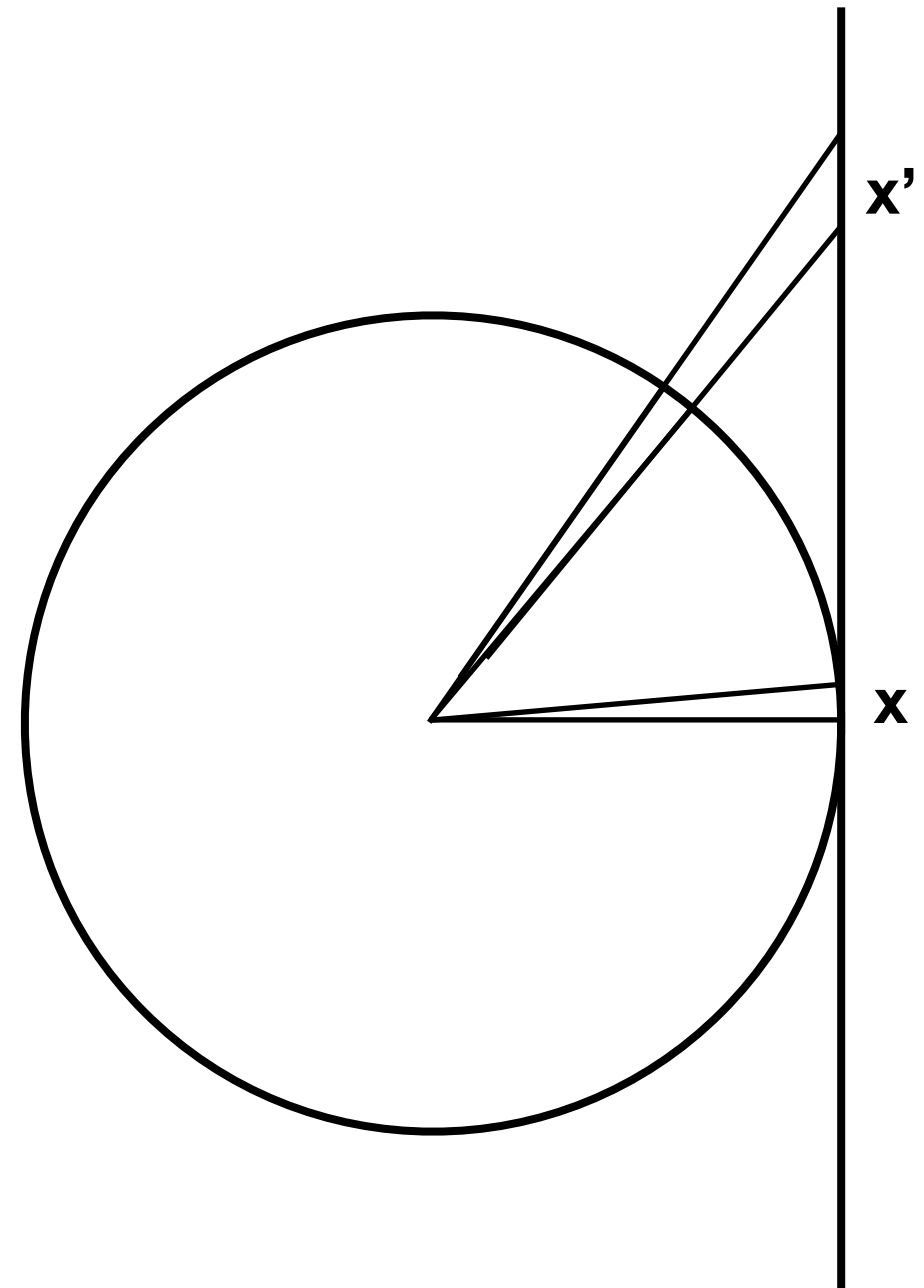
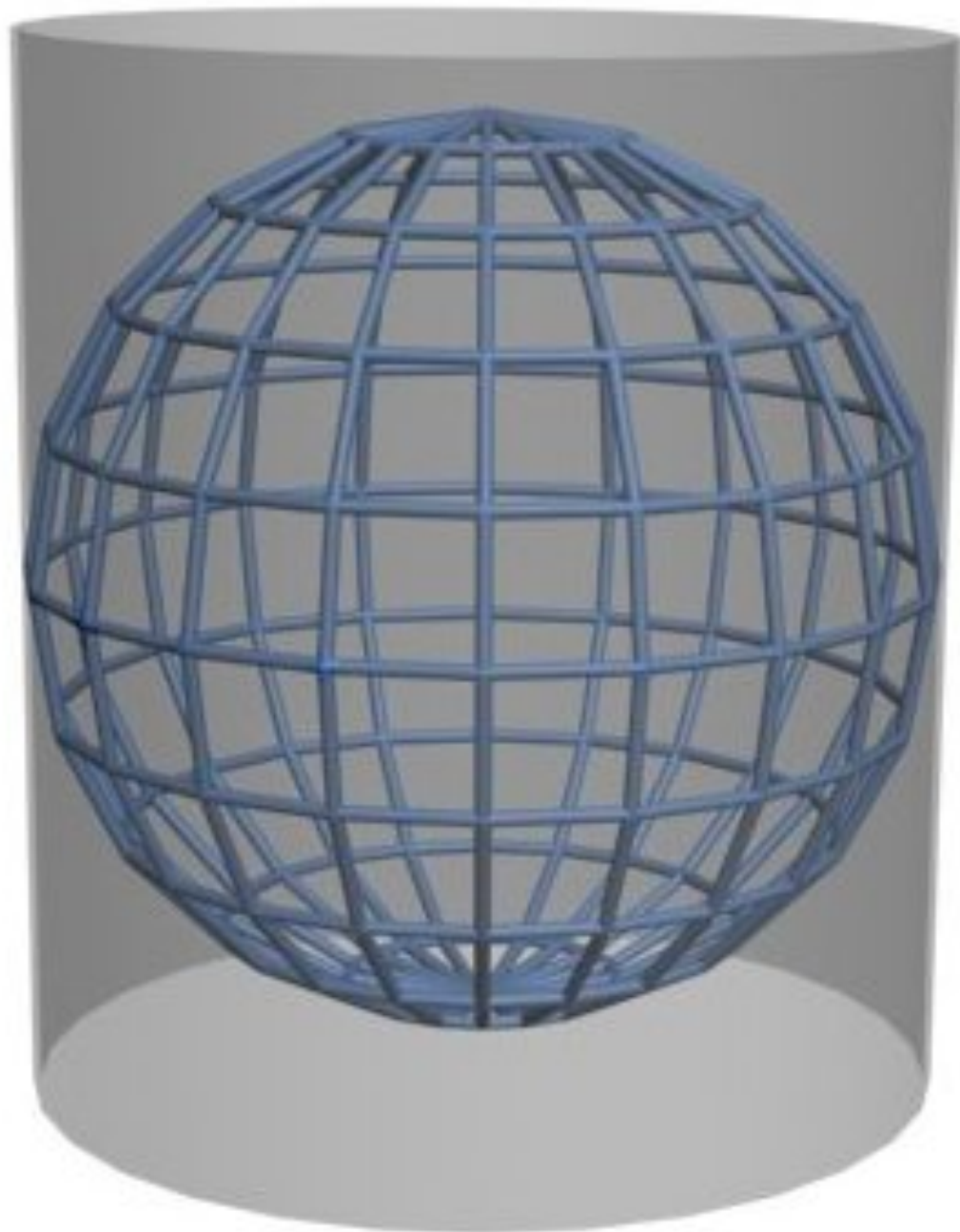


DANE GEOPRZESTZENNE



lat, lng

ODWZOROWANIE KARTOGRAFICZNE



ODWZOROWANIE KARTOGRAFICZNE





Playing with web app

<https://github.com/to-masz/s2examples>

PODEJŚCIE KLASYCZNE

```
CREATE TABLE `geospatial`.`example` (  
  `id` INT NOT NULL AUTO_INCREMENT,  
  `name` VARCHAR(45) NOT NULL,  
  `lat` DECIMAL(10,8) NOT NULL,  
  `lng` DECIMAL(11,8) NOT NULL,  
  PRIMARY KEY (`id`));
```

“good old days”

```
CREATE TABLE `geospatial`.`example` (  
  `id` INT NOT NULL AUTO_INCREMENT,  
  `name` VARCHAR(45) NOT NULL,  
  `point` POINT() NOT NULL,  
  PRIMARY KEY (`id`),  
  SPATIAL INDEX `geoindex` (`point` ASC));
```

OpenGIS

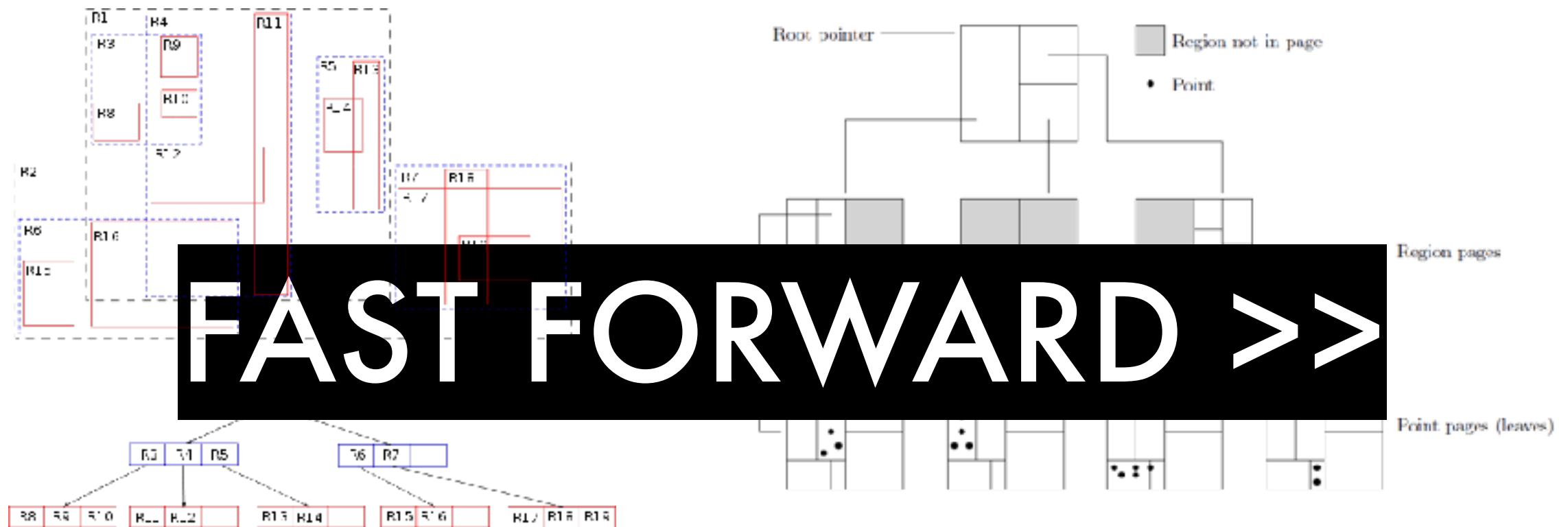
PUT example

```
{  
  "mappings": {  
    "my_type": {  
      "properties": {  
        "location": {  
          "type": "geo_point"  
        }  
      }  
    }  
  }  
}
```

Geo-point datatype

ALGORITHMS

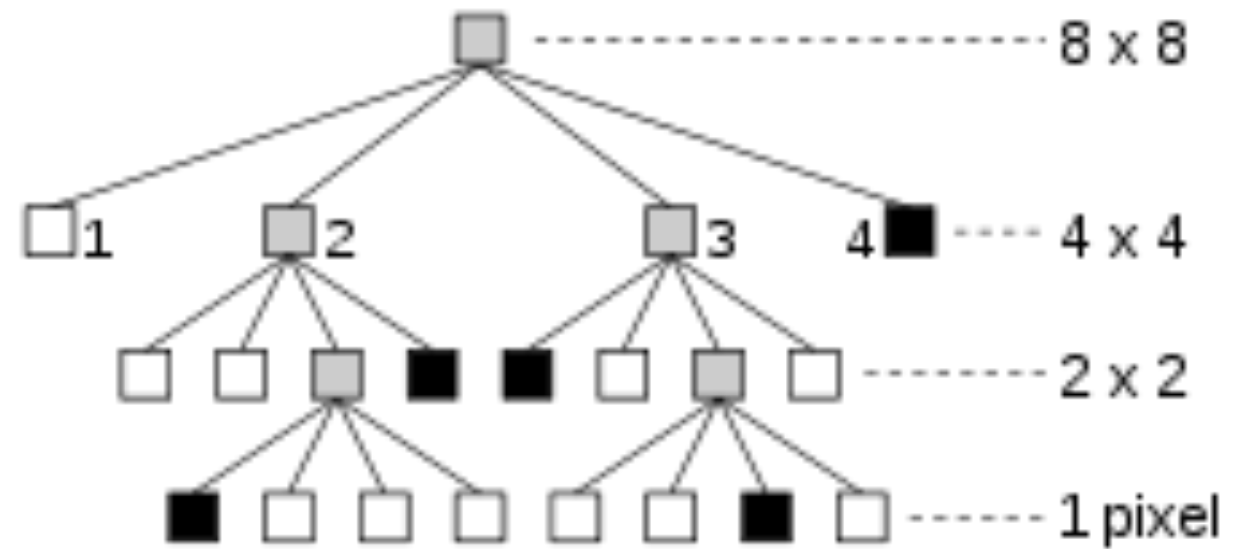
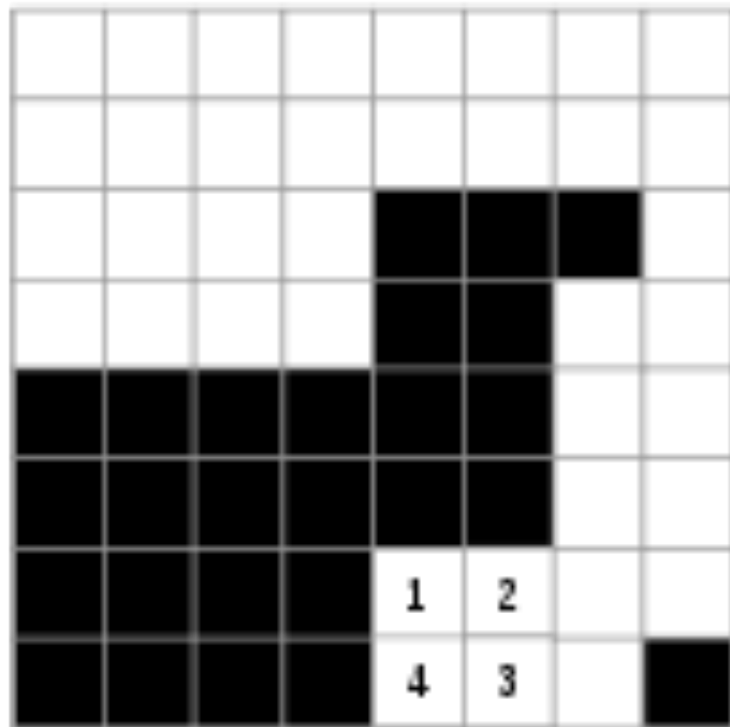
- ▶ R-trees
- ▶ K-trees
- ▶ K-D-B trees



DAMN COOL ALGORITHMS

- ▶ Quadtrees
- ▶ Geohashes
- ▶ S2

QUADTREES



QUADTREES



QUADTREES



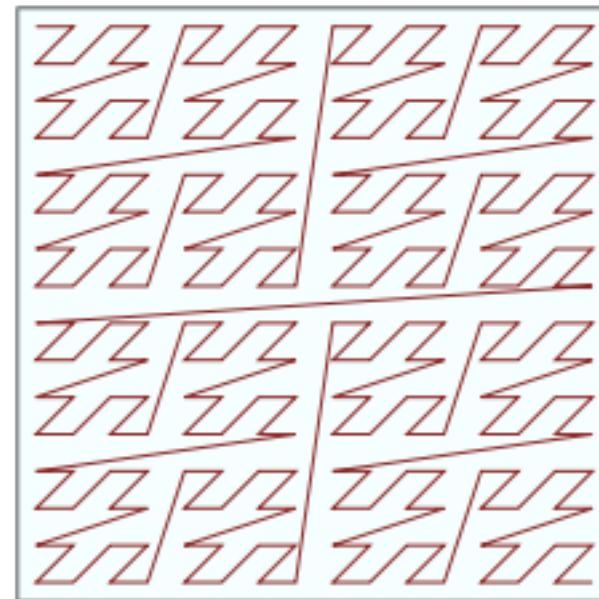
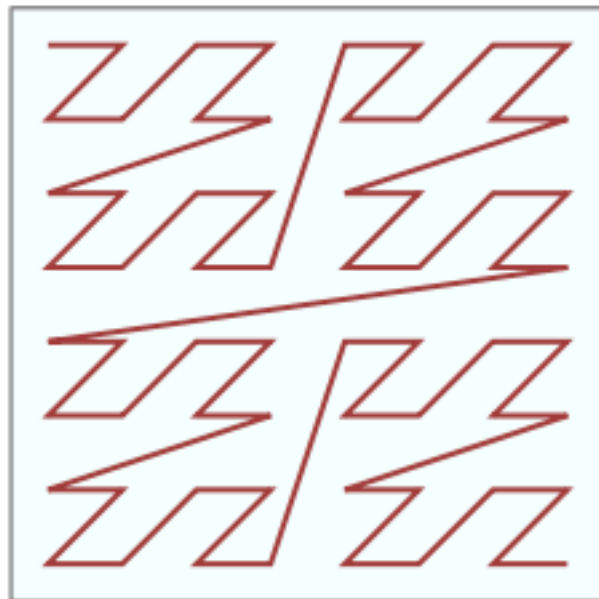
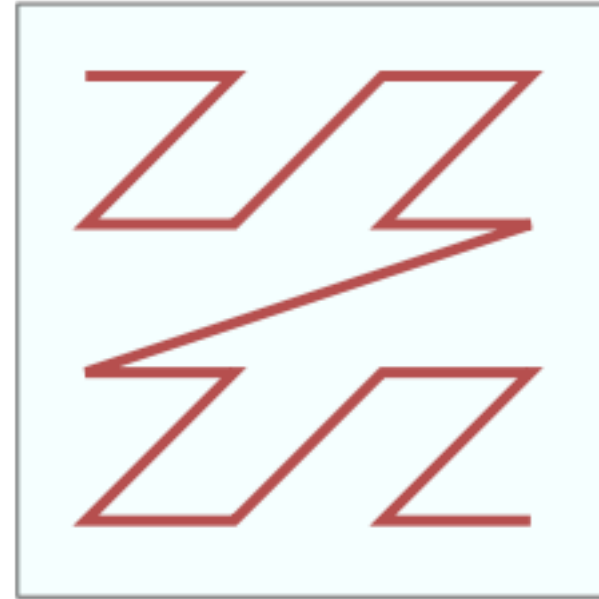
QUADTREES



GEOHASHES



GEOHASHES



GEOHASHES



GEOHASHES BASE-32

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
00000	00001	00010	00011	00100	00101	00110	00111	01000	01001	01010	01011	01100	01101	01110	01111
0	1	2	3	4	5	6	7	8	9	b	c	d	e	f	g

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
10000	10001	10010	10011	10100	10101	10110	10111	11000	11001	11010	11011	11100	11101	11110	11111
h	j	k	m	n	p	q	r	s	t	u	v	w	x	y	z

011011



01101 1????



e



23, -23

GEOHASHES

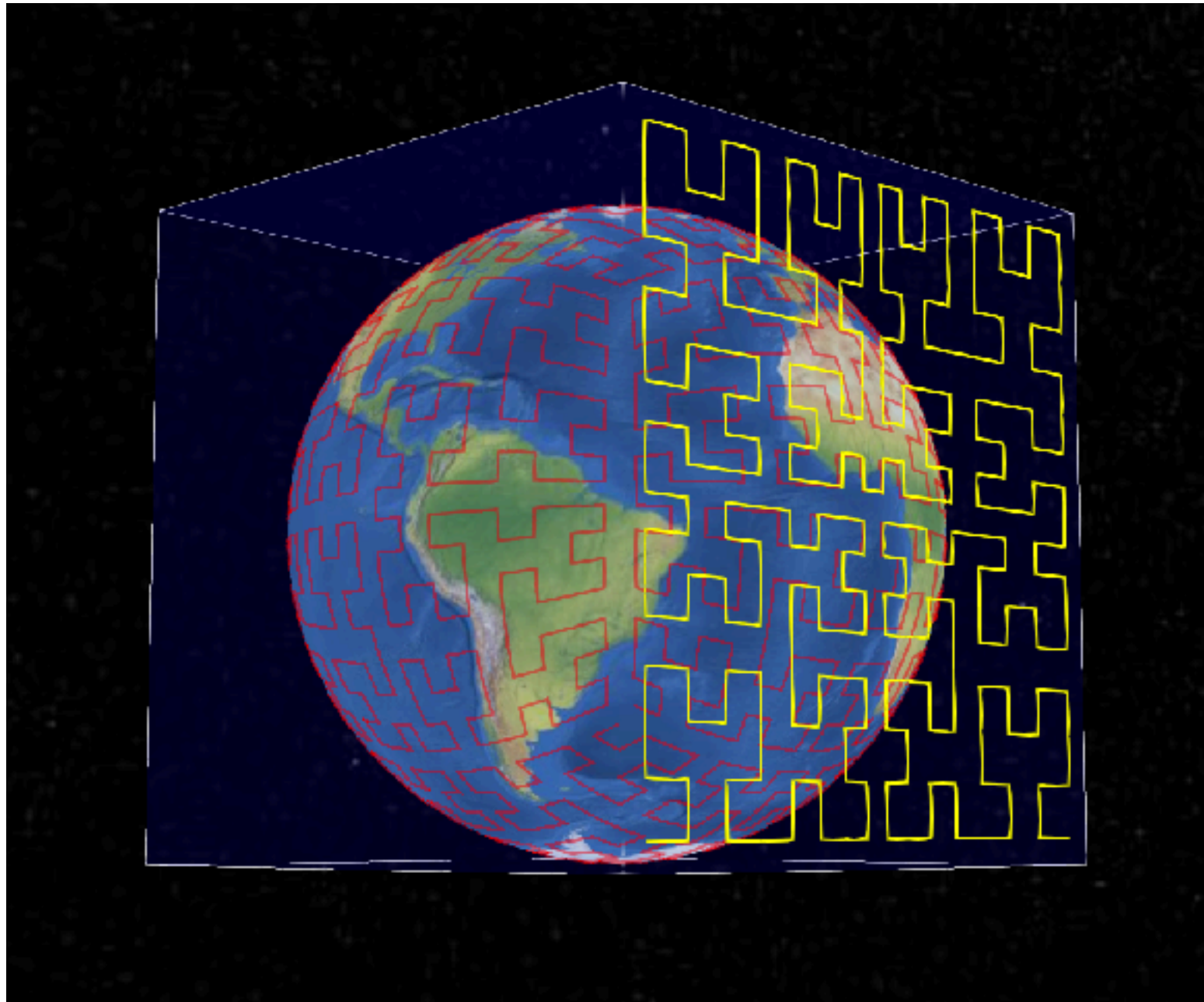
```
ST_GeoHash(180, 0, 10)
```

```
POST /example/_search?size=0
{
  "aggregations" : {
    "large-grid" : {
      "geohash_grid" : {
        "field" : "location",
        "precision" : 3
      }
    }
  }
}
```

S2 GOALS

- ▶ Hierarchical decomposition of the sphere into “cells”
- ▶ Ability to approximate regions using cells
- ▶ Compact representation of each cell
- ▶ Fast methods for querying with arbitrary regions
- ▶ All cells at a given level should have similar area

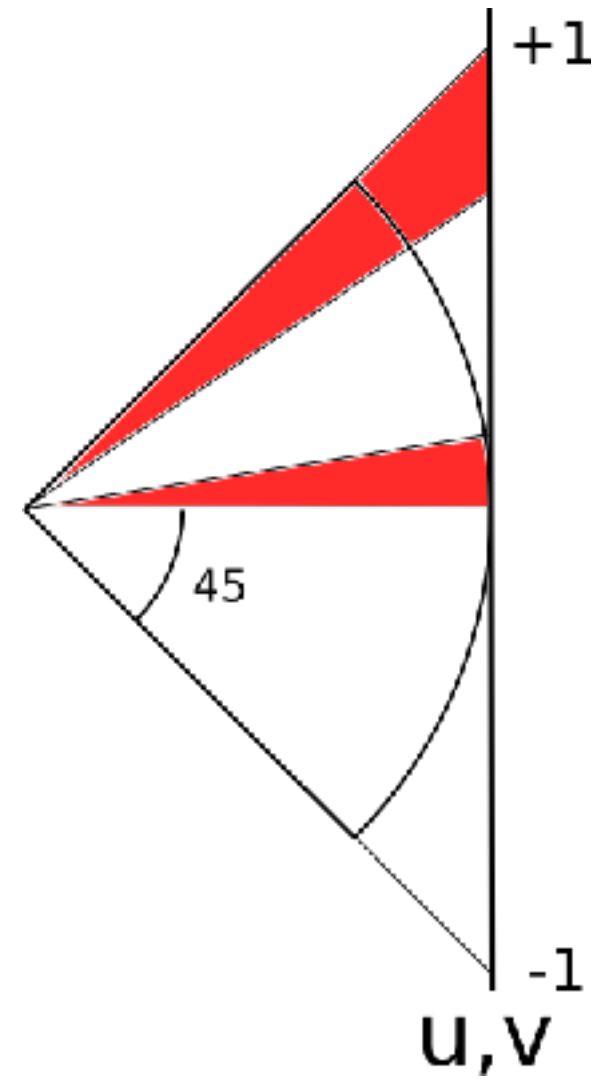
S2



S2

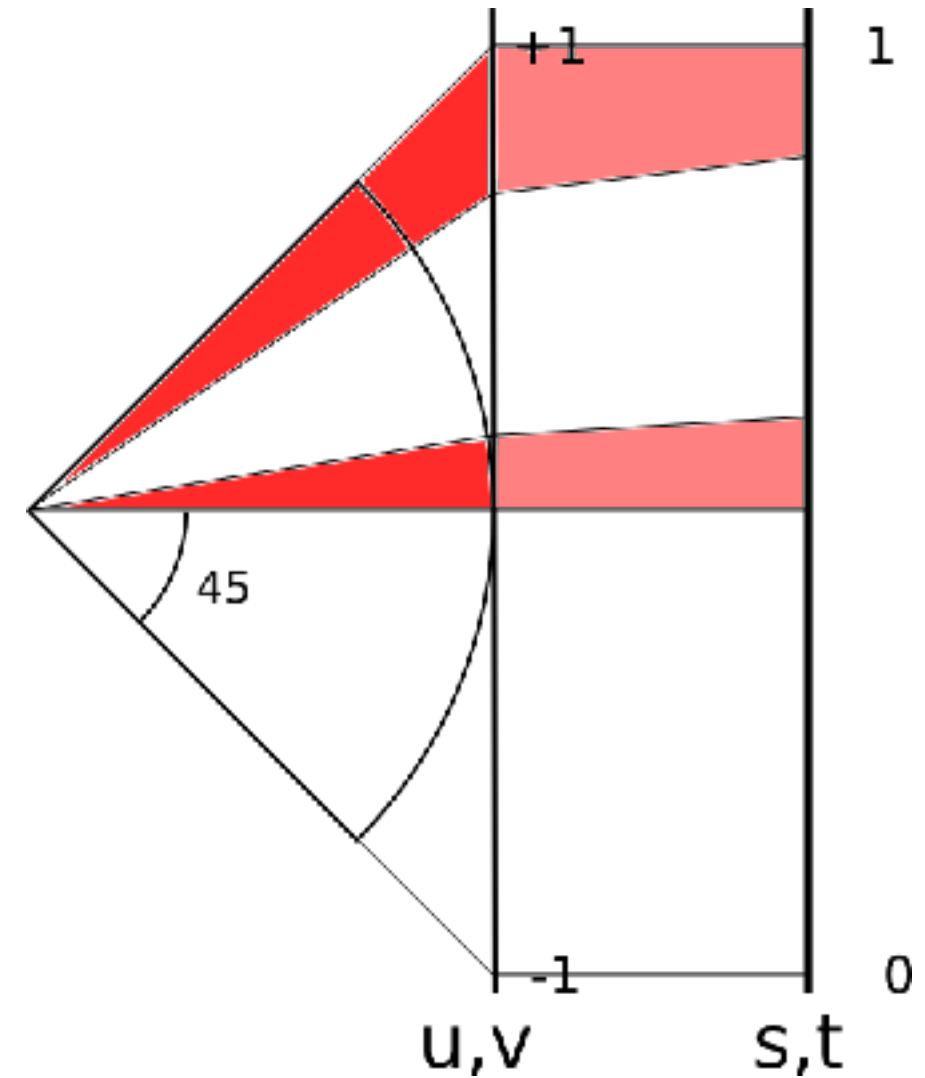
1. $p=(\text{lat}, \text{lng}) \Rightarrow (x, y, z)$

2. $(x, y, z) \Rightarrow (\text{face}, u, v)$



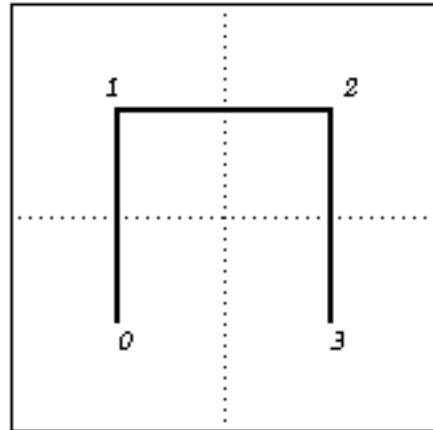
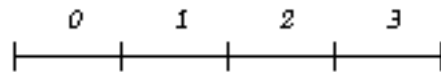
S2

1. $p=(\text{lat}, \text{lng}) \Rightarrow (x, y, z)$
2. $(x, y, z) \Rightarrow (\text{face}, u, v)$
3. $(\text{face}, u, v) \Rightarrow (\text{face}, s, t)$

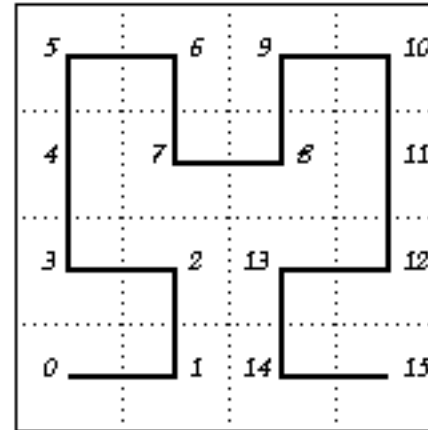
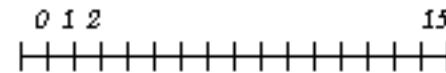


The Hilbert Curve

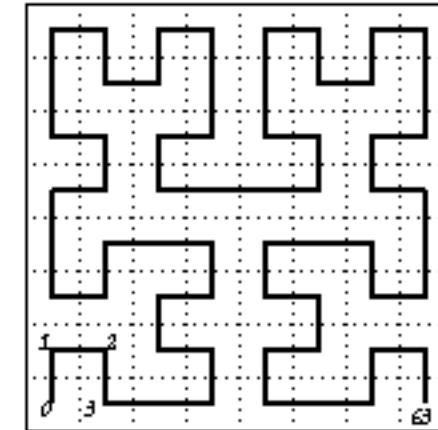
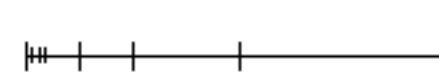
First Order



Second Order

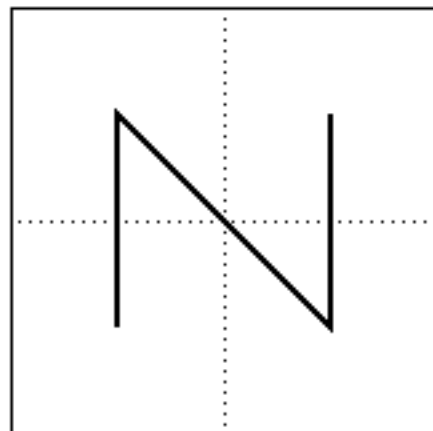


Third Order

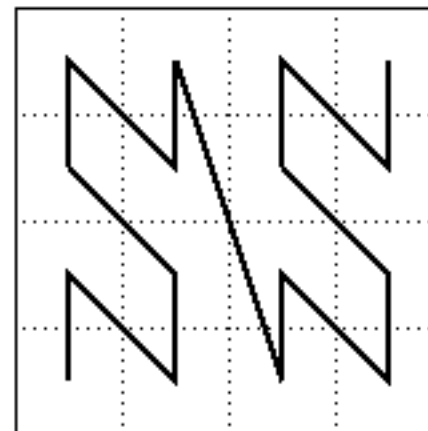


The Z-Order Curve

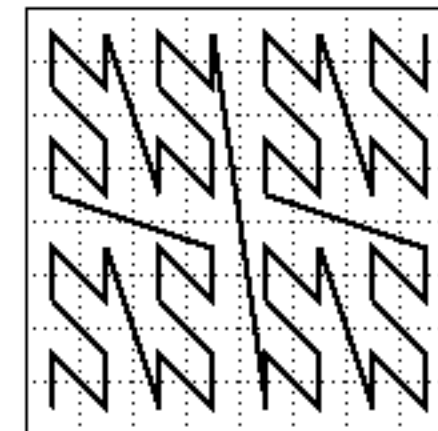
First Order



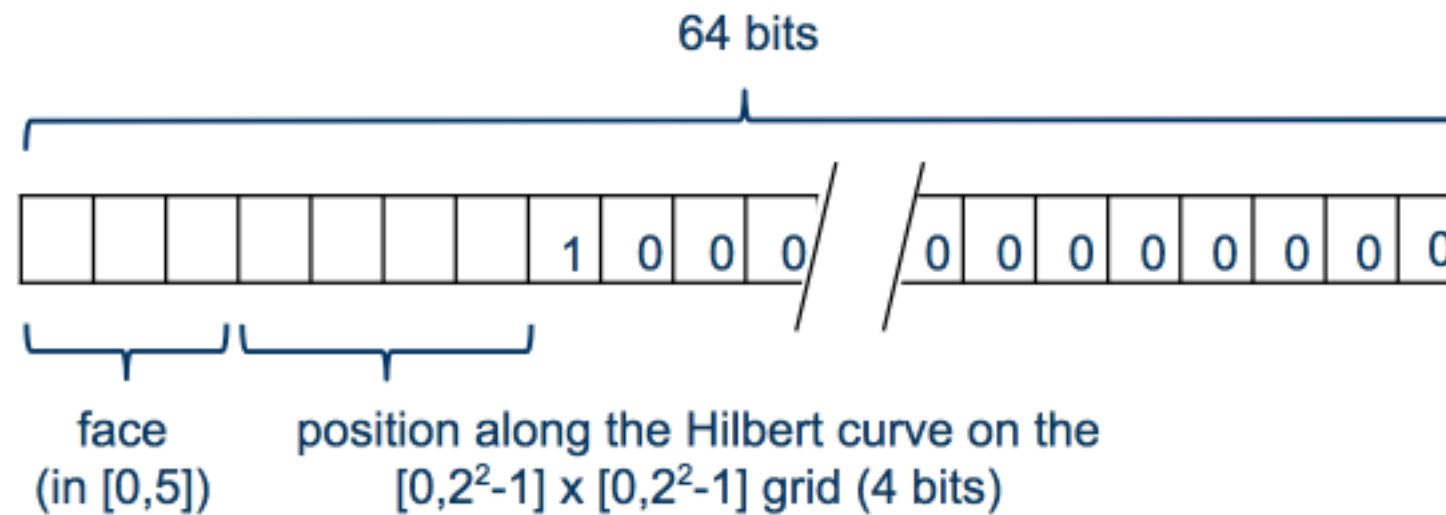
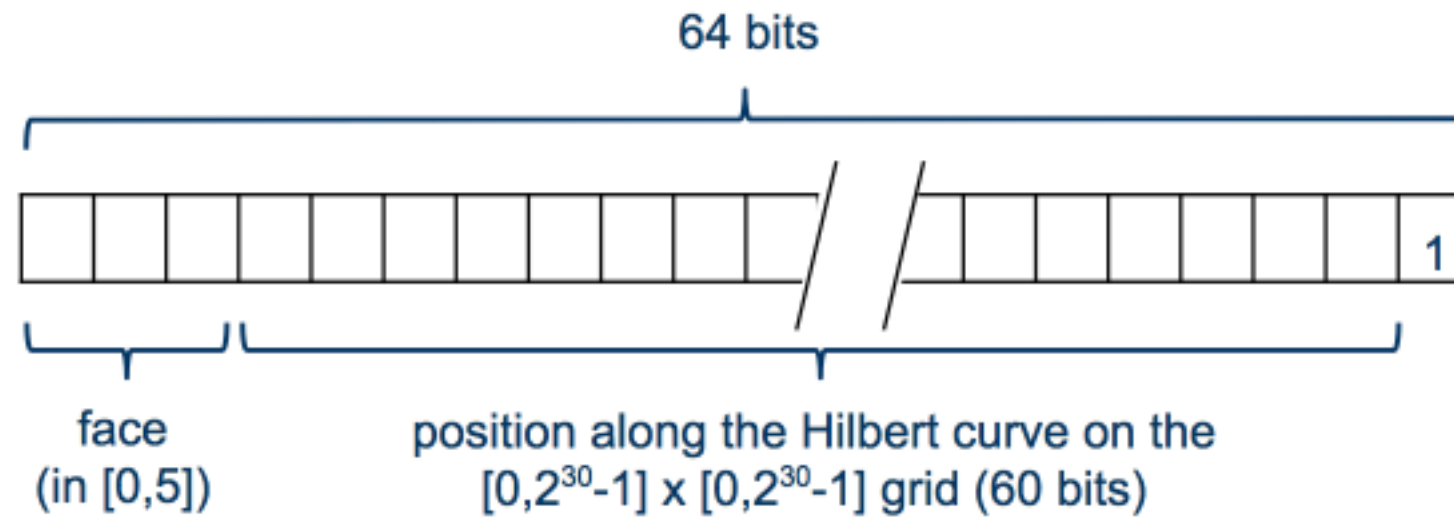
Second Order



Third Order



S2 CELL HIERARCHY



S2 CELL HIERARCHY

Level	Min Area	Max Area
0	85,011,012 km ²	85,011,012 km ²
1	21,252,753 km ²	21,252,753 km ²
12	3.31 km ²	6.38 km ²
30	0.48 cm ²	0.93 cm ²

S2 LIBRARY

```
composer require NicklasWallgren/s2-geometry-library-php
```



port oryginalnej biblioteki c++
nadal wymaga drobnych poprawek ;)

HAVING FUN WITH

S2

<https://github.com/to-masz/s2examples>

S2 IN MYSQL

```
$statement = $pdo->prepare("INSERT INTO example(id, s2cell)  
VALUES(:id, :s2)");
```

```
$statement->bindParam(':id', $id, PDO::PARAM_INT);  
$statement->bindParam(':s2', $cellId, PDO::PARAM_LOB);
```

```
$statement->execute();
```

```
$mask = S2CellId::lowestOnBitForLevel($level);  
$where[] = '((s2 & -:parentmask) | :parentmask = :id)';
```


DZIEŃKI!!

REFERENCES

Hilbert Curve

- ▶ <http://bit-player.org/extras/hilbert/hilbert-mapping.html>
- ▶ <https://xkcd.com/195/>
- ▶ <http://datagenetics.com/blog/march22013/index.html>

S2

- ▶ <http://blog.christianperone.com/2015/08/googles-s2-geometry-on-the-sphere-cells-and-hilbert-curve/>
- ▶ https://docs.google.com/presentation/d/1HI4KapfAENAO4gv-pSngKwvS_jwNVHRPZTTDzXXn6Q/view
- ▶ <https://medium.com/sidewalk-talk/s2-cells-and-space-filling-curves-keys-to-building-better-digital-map-tools-for-cities-a312aa5e2f59>
- ▶ <https://github.com/sidewalklabs/s2sphere/blob/6ca8754d2473081e869935f4596aeb8bc3958ba6/s2sphere/sphere.py>

Others

- ▶ <http://opensourceconnections.com/blog/2014/04/11/indexing-polygons-in-lucene-with-accuracy/>
- ▶ <https://en.wikipedia.org/wiki/Geohash>
- ▶ https://en.wikipedia.org/wiki/Z-order_curve
- ▶ <http://blog.notdot.net/2009/11/Damn-Cool-Algorithms-Spatial-indexing-with-Quadtrees-and-Hilbert-Curves>
- ▶ <https://en.wikipedia.org/wiki/K-D-B-tree>
- ▶ <https://en.wikipedia.org/wiki/Trie>
- ▶ <https://dev.mysql.com/doc/refman/5.7/en/spatial-extensions.html>