## nomineł

## Fun with IPv4 Heatmaps

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Nominet UK

# Open Resolver Addresses <br> Mapped in Hilbert Order <br> Colored by /24 saturation 

code: Duane Wessels
data: John Kristoff


More than 16,000,000 open resolvers during a sweep of the IPv4 address space.


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detail of 80.0.0.0/4
One /24 network per pixel, colored by saturation.


BGP Routeviews


## BGP Routeviews



RIR whois


## Open Resolvers



Census


Inspired by XKCD


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## Examples of Heatmaps



Ed Parsons "the Cathedral and the GPS" footprints of google's KML/GeoRSS database


## Eyetools heatmaps <br> Where do viewers look and click



## GeoIQ <br> Heatmap layer for Google maps



IPv4 Heatmap in Hilbert Order.


Hilbert curves, order 1 to 6 Direction changes with every order

$$
\begin{array}{rrrr}
1 & 2 & 15 & 16 \\
4 & 3 & 14 & 13 \\
& & & \\
5 & 8 & 9 & 12 \\
6 & 7 & 10 & 11
\end{array}
$$

16 points on a $2^{\text {nd }}$ order hilbert curve

Using Hilbert Curves:
Consecutive netblocks can be grouped together.

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However
In networking, only those consecutive netblocks that share the same prefix need to be grouped together.

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However
In networking, only those consecutive netblocks that share the same prefix need to be grouped together.

$$
127 / 8+128 / 8!=127 / 7
$$

## Using Morton Curves:

consecutive netblocks that share the prefix can be grouped as one netblock.

Which is tailored to our needs.


Morton curves, order 1 to 4 Direction is the same with every order

$$
\begin{array}{rrrr}
1 & 2 & 5 & 6 \\
3 & 4 & 7 & 8 \\
& & & \\
9 & 10 & 13 & 14 \\
11 & 12 & 15 & 16
\end{array}
$$

16 points on $2^{\text {nd }}$ order Morton curve


IPv4 Heatmap in Hilbert Order.

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IPv4 Heatmap in Morton Order.


Hilbert

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| $\checkmark \underbrace{}_{56,0.0 .0 / 8} D^{\infty}$ | - $\underset{57.0 .0 .0 / 8}{\sim} \overbrace{1}^{\sim}$ |  |  |
|  |  |  |  |

Morton

Detail of $48 / 4$


Hilbert
Morton

Detail of $48 / 4$

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IPv4 Heatmap in Morton Order.

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## IPv4 Heatmap in Morton Order.

 Notice the very red spot.

This is a /16 network

These curves work in three dimensions


3 D IFw' Heatmap ' Nominet LK


3D IFw4 Heatmap, 'Nominet UK

Color map: GOEI viewnade: total, travel transparency: 0.50 pointsive: 2.7 netblock: 10.0 .0 .018 Threshold: 64, 255
Ypos: 12
Ypos:315

3D IFw4 Heatmap ; Nominet LIK

Color map: GDEl
viewmode: totol, travel
transparency : 0.23
pointsize: 2.5
netblock: 1270.0.0 0
Threshold: 8, 255


Xpos: 27
Ypos:141

Color map: GBEI
wiewmode: total, trawel
transparency: 0.23
pointsize: 2.5
netalock: 127.0 .018
Threshold: 8, 255


Xpos: 27
Ypos:141

3D IFw4 Heatmap / Nominet LIK

Color map: GOBI
wiewmade: total, travel
transparency: 0.23
pointsize: 2.5
metblock: 224.0.0.0/3
Threshole: 8, 255
Mpos: 3
Ypos:192


Color map: GiOBI
viewnode: cubse, focus
transparency: 0.23
pointsize: 1.6
netblack: 151.89.0.0;16
Threshold: 4, 255
Xpos: 12
Ypos:192

3D IFv4 Heatmap / Nominet UK

Color map: CODE
viewnode: cubse, focus
transparency: 0.23
pointsize: 4.8
netblack: 151.89.0.0;16
Threstiold: 4, 255
Xpos: 27
Ypos:204

