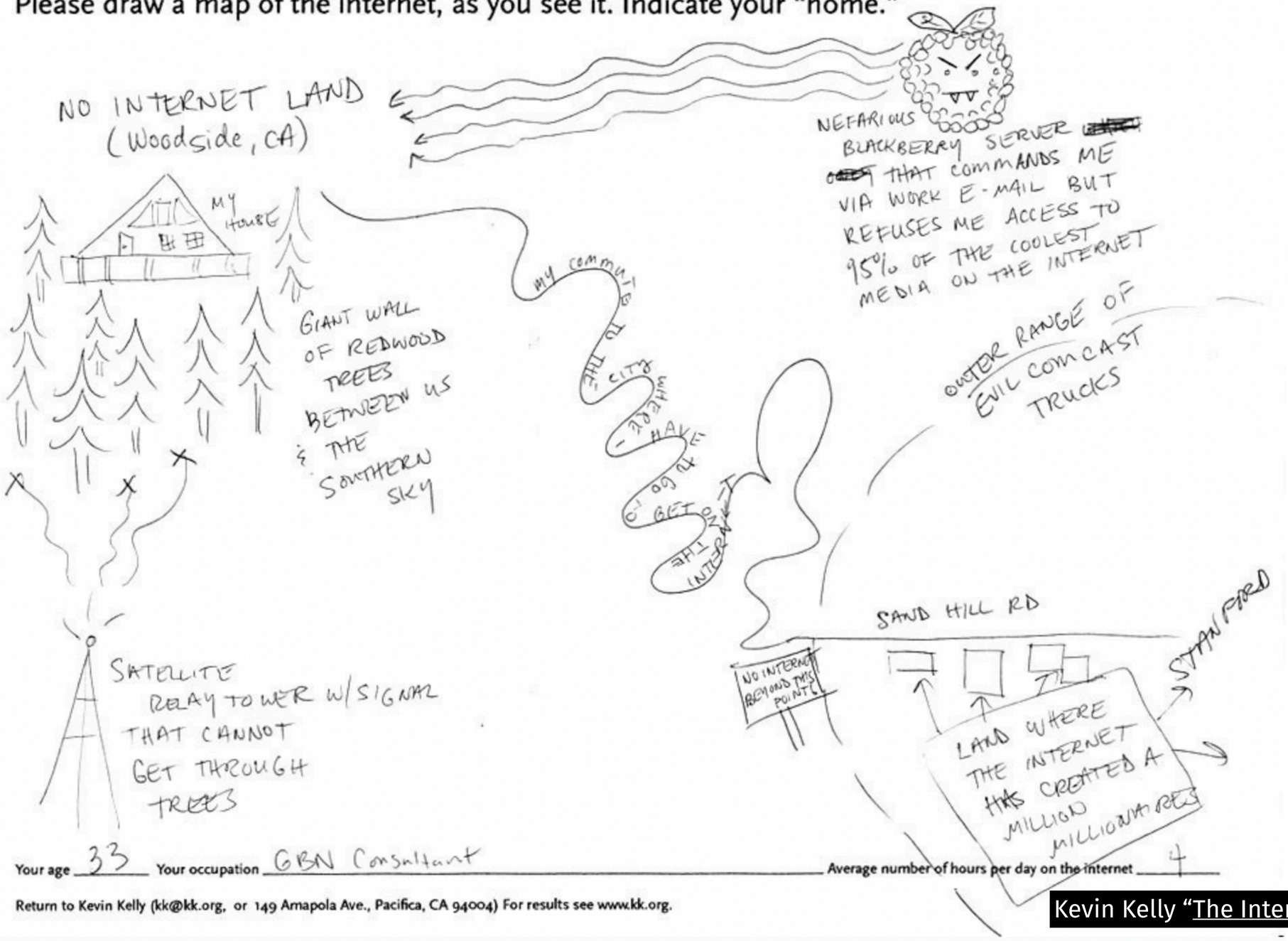
# Towards an interactive visualization of the Internet

**Maxime Mouchet — LIP6, Sorbonne Université**

# THE INTERNET MAPPING PROJECT

Please draw a map of the internet, as you see it. Indicate your "home."




Your age 33 Your occupation GBN Consultant Average number of hours per day on the internet 4

Return to Kevin Kelly (kk@kk.org, or 149 Amapola Ave., Pacifica, CA 94004) For results see www.kk.org.

Kevin Kelly "The Internet Mapping Project"

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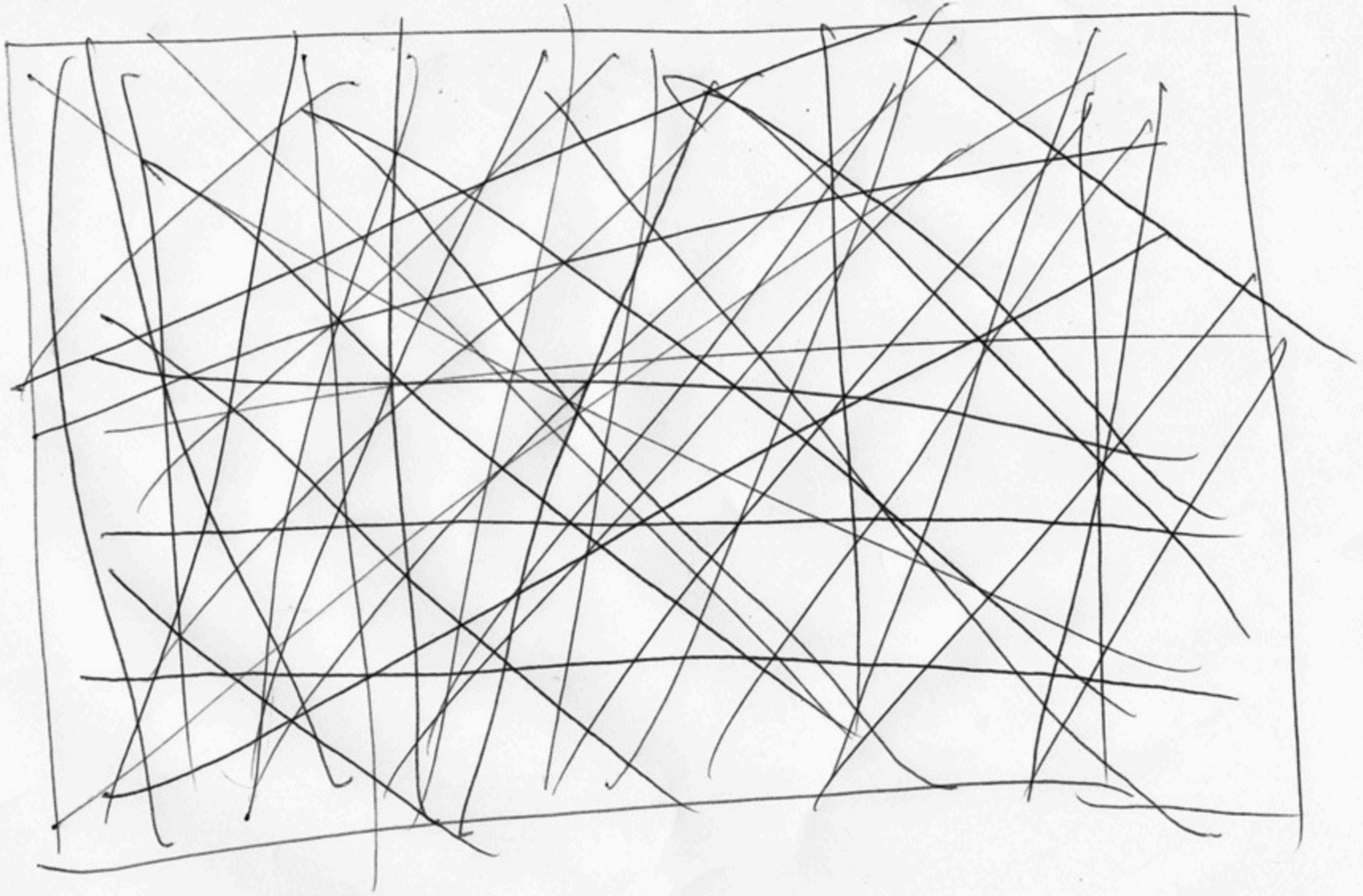

Your age _____ Your occupation _____ Average number of hours per day on the internet _____

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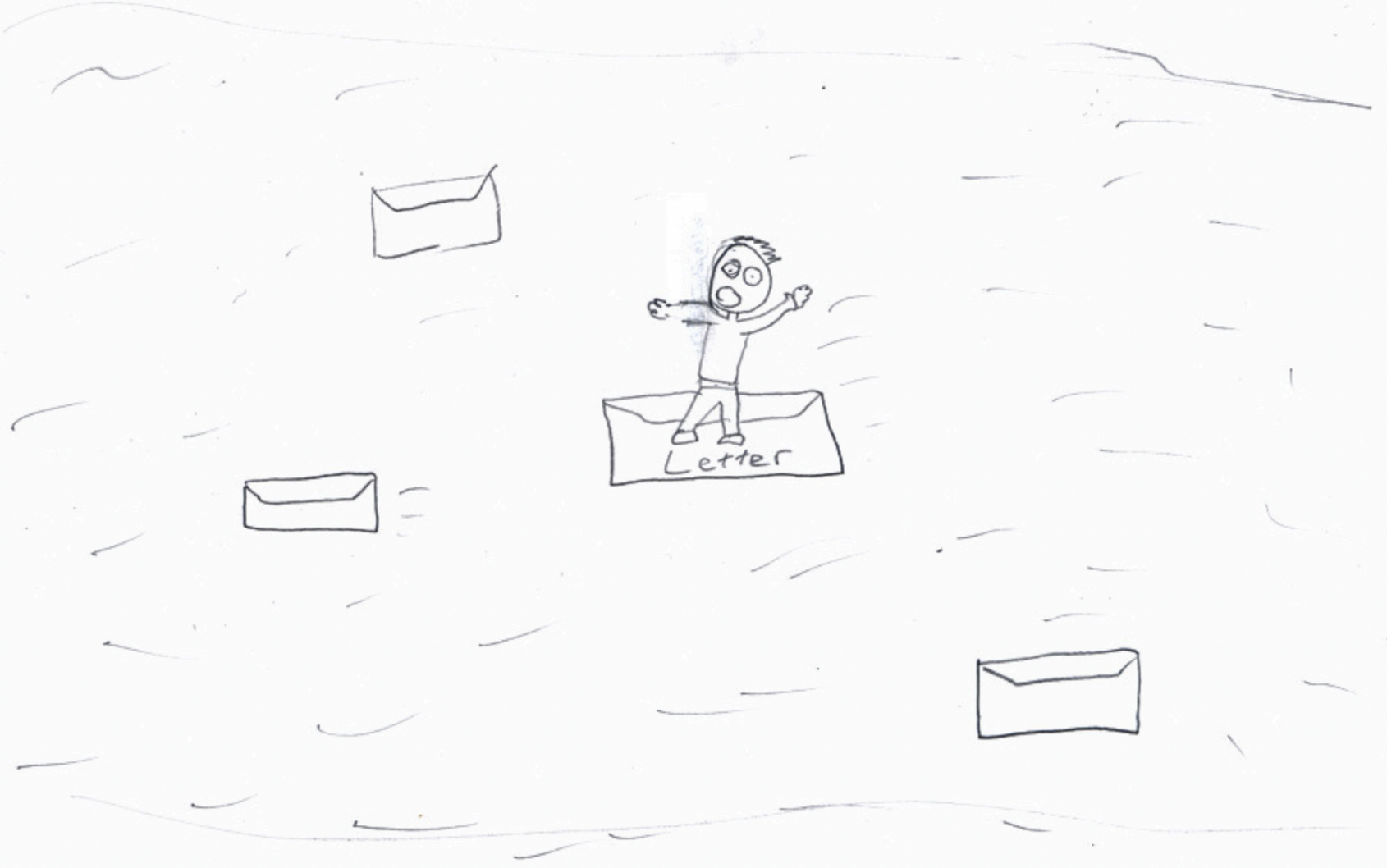


Your age 13 Your occupation School Average number of hours per day on the internet 1 hour on weekends

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Kevin Kelly "The Internet Mapping Project"

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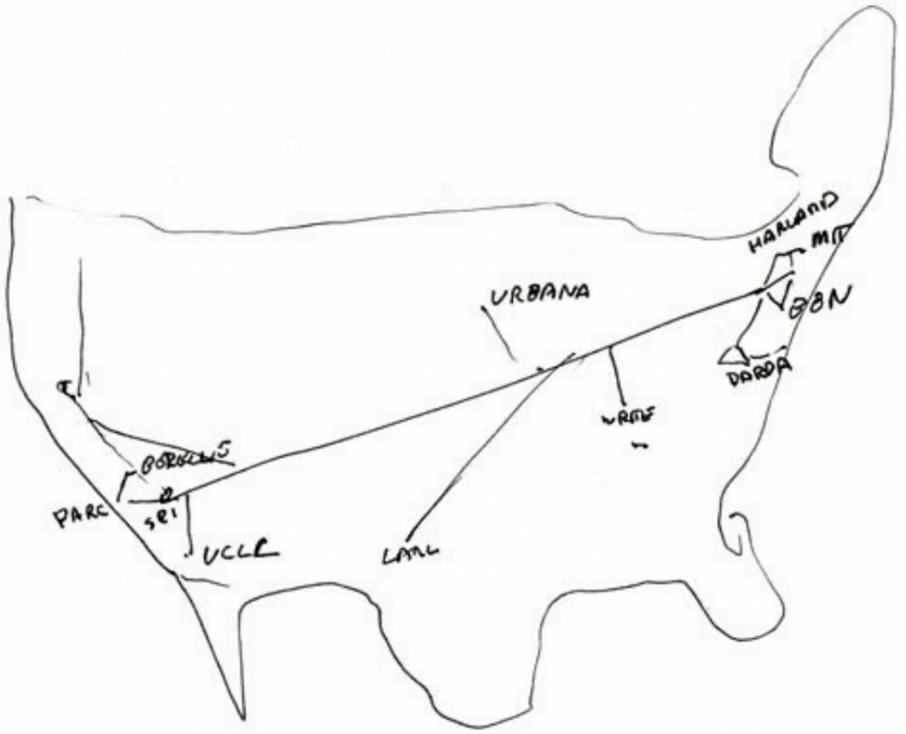


Your age 53 Your occupation Inventor Average number of hours per day on the internet _____

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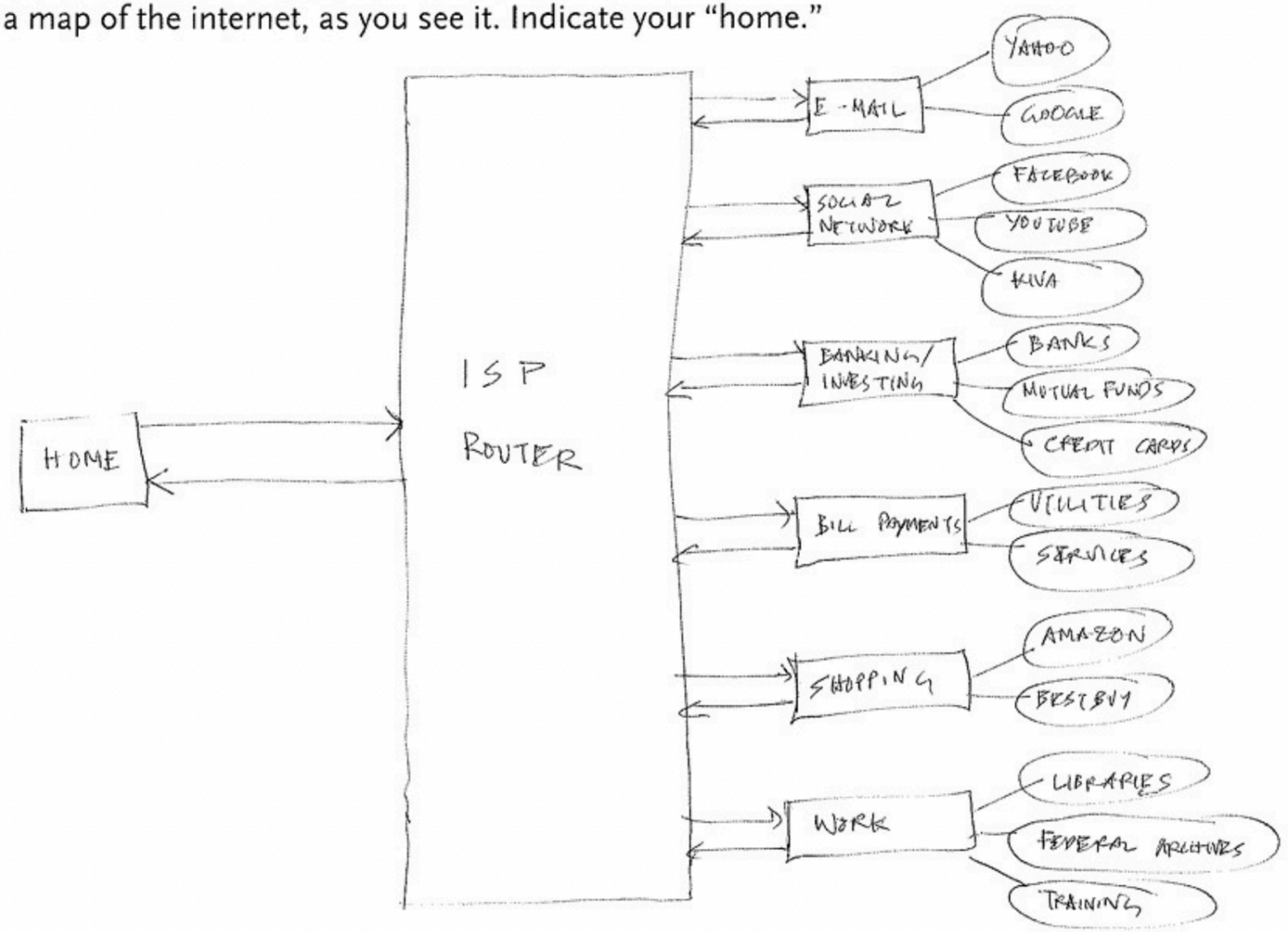
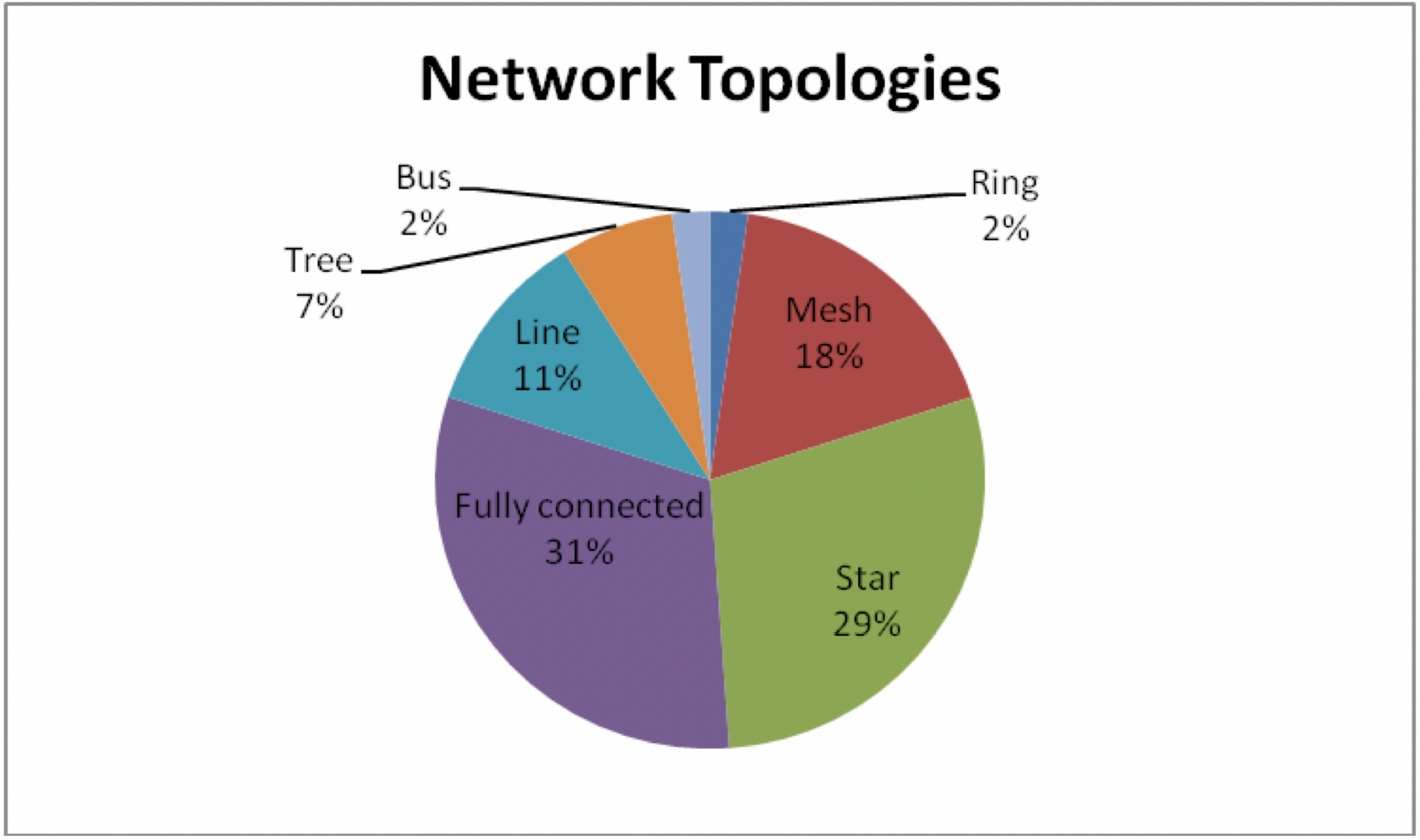



Your age 39 Your occupation ENGINEER Average number of hours per day on the internet 12

Return to Kevin Kelly (kk@kk.org, or 149 Amapola Ave., Pacifica, CA 94004) For results see www.kk.org.

Kevin Kelly "The Internet Mapping Project"


Network Topologies
Bus
2%
Ring
2%
Tree
7%
Line
11%
Mesh
18%
Fully connected
31%
Star
29%

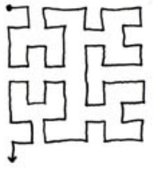
Graphic 1

# MAP OF THE INTERNET

THE IPv4 SPACE, 2006

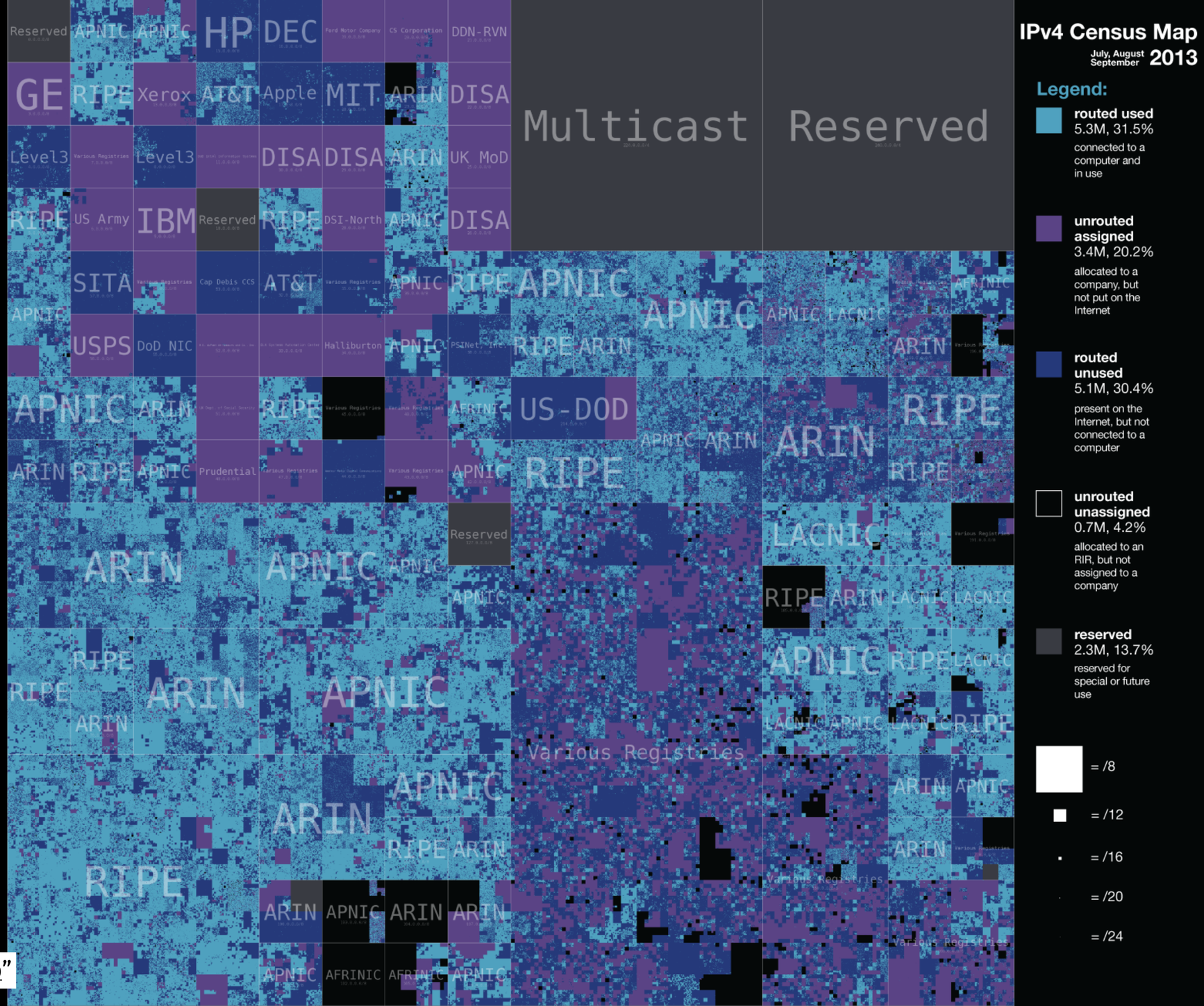
THIS CHART SHOWS THE IP ADDRESS SPACE ON A PLANE USING A FRACTAL MAPPING WHICH PRESERVES GROUPING -- ANY CONSECUTIVE STRING OF IPs WILL TRANSLATE TO A SINGLE COMPACT, CONTIGUOUS REGION ON THE MAP. EACH OF THE 256 NUMBERED BLOCKS REPRESENTS ONE /8 SUBNET (CONTAINING ALL IPs THAT START WITH THAT NUMBER). THE UPPER LEFT SECTION SHOWS THE BLOCKS SOLD DIRECTLY TO CORPORATIONS AND GOVERNMENTS IN THE 1990's BEFORE THE RIRs TOOK OVER ALLOCATION.

0 1 14 15 16 19 →
3 2 13 12 17 18
4 7 8 11
5 6 9 10

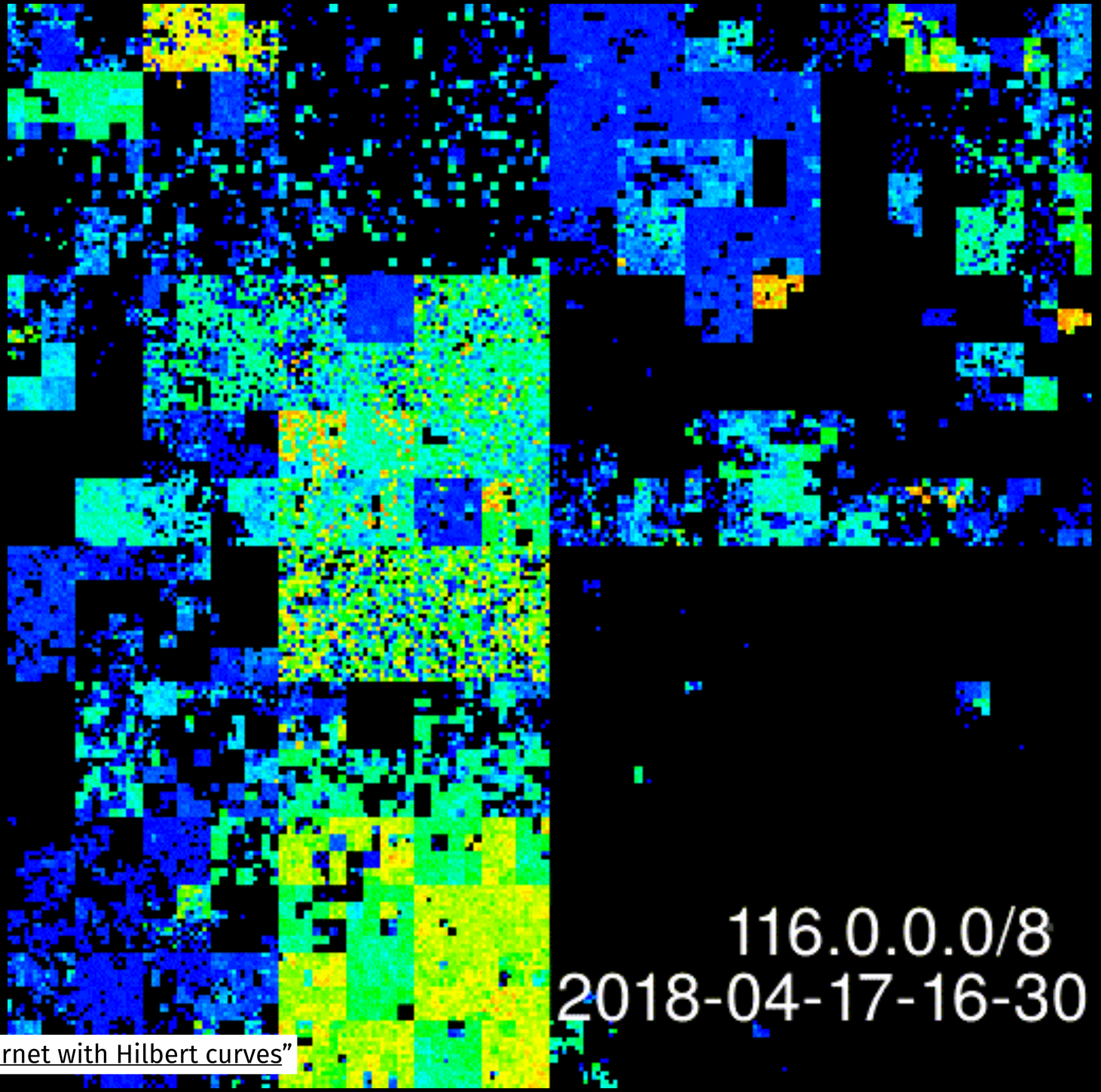


= UNALLOCATED BLOCK

Randall Munroe “xkcd 195”

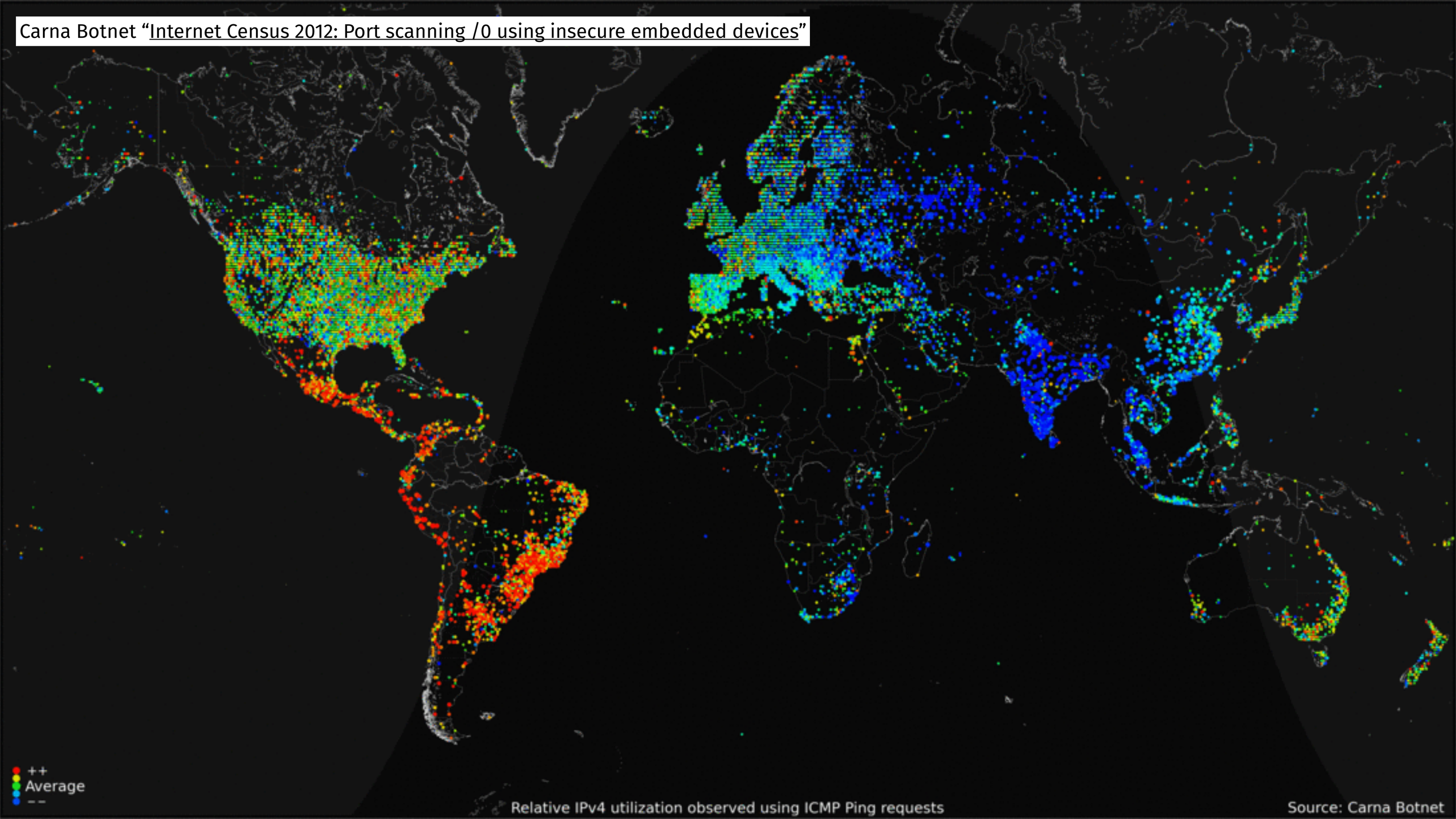



CAIDA “IPv4 Census Map”




Ben Cox “Mapping the whole internet with Hilbert curves”

Carna Botnet “Internet Census 2012: Port scanning /0 using insecure embedded devices”



# Submarine Cable Map 2021

TeleGeography | telecomegypt

Designed and produced by TeleGeography
One Thomas Circle NW, Suite 360, Washington, DC 20005, USA
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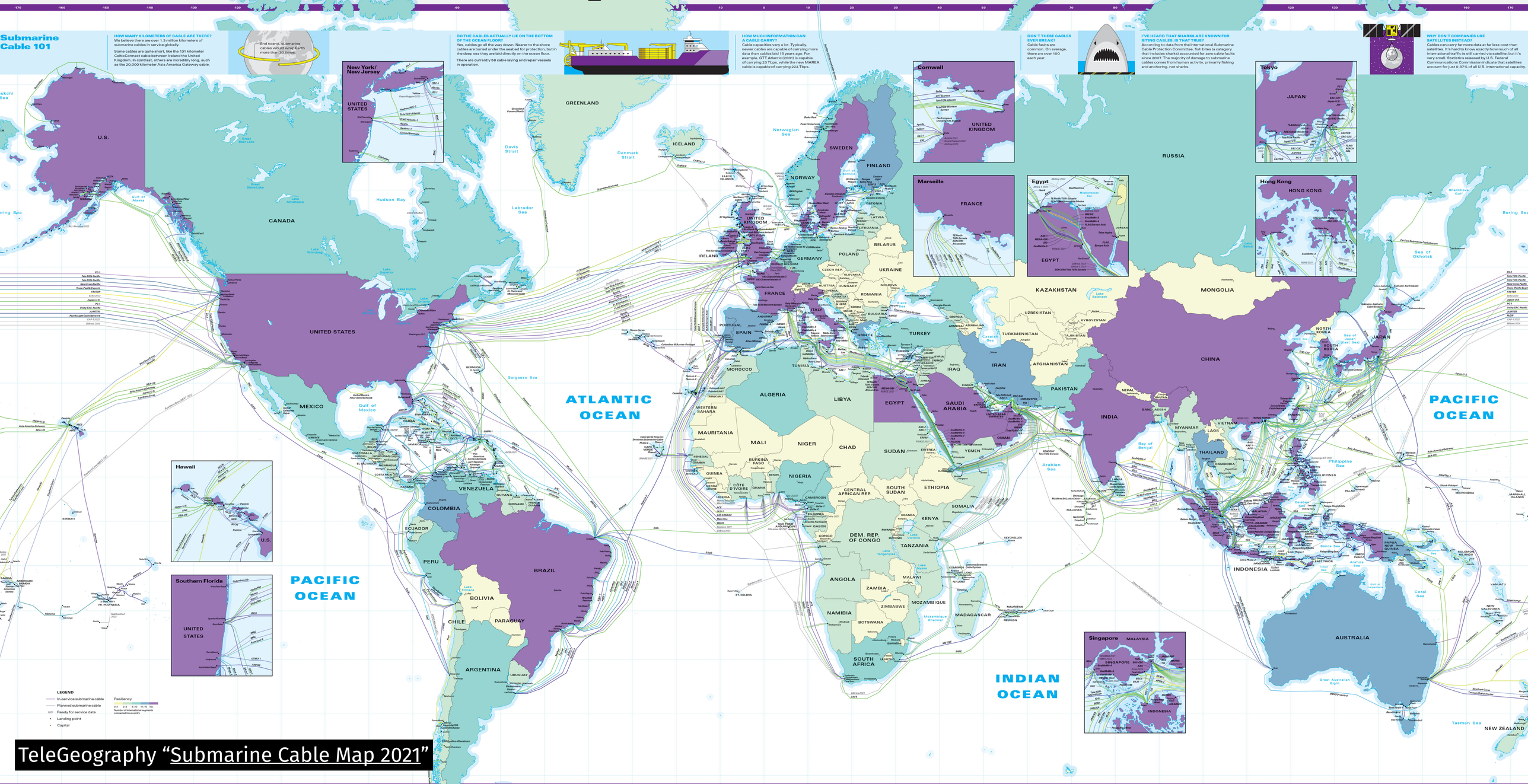
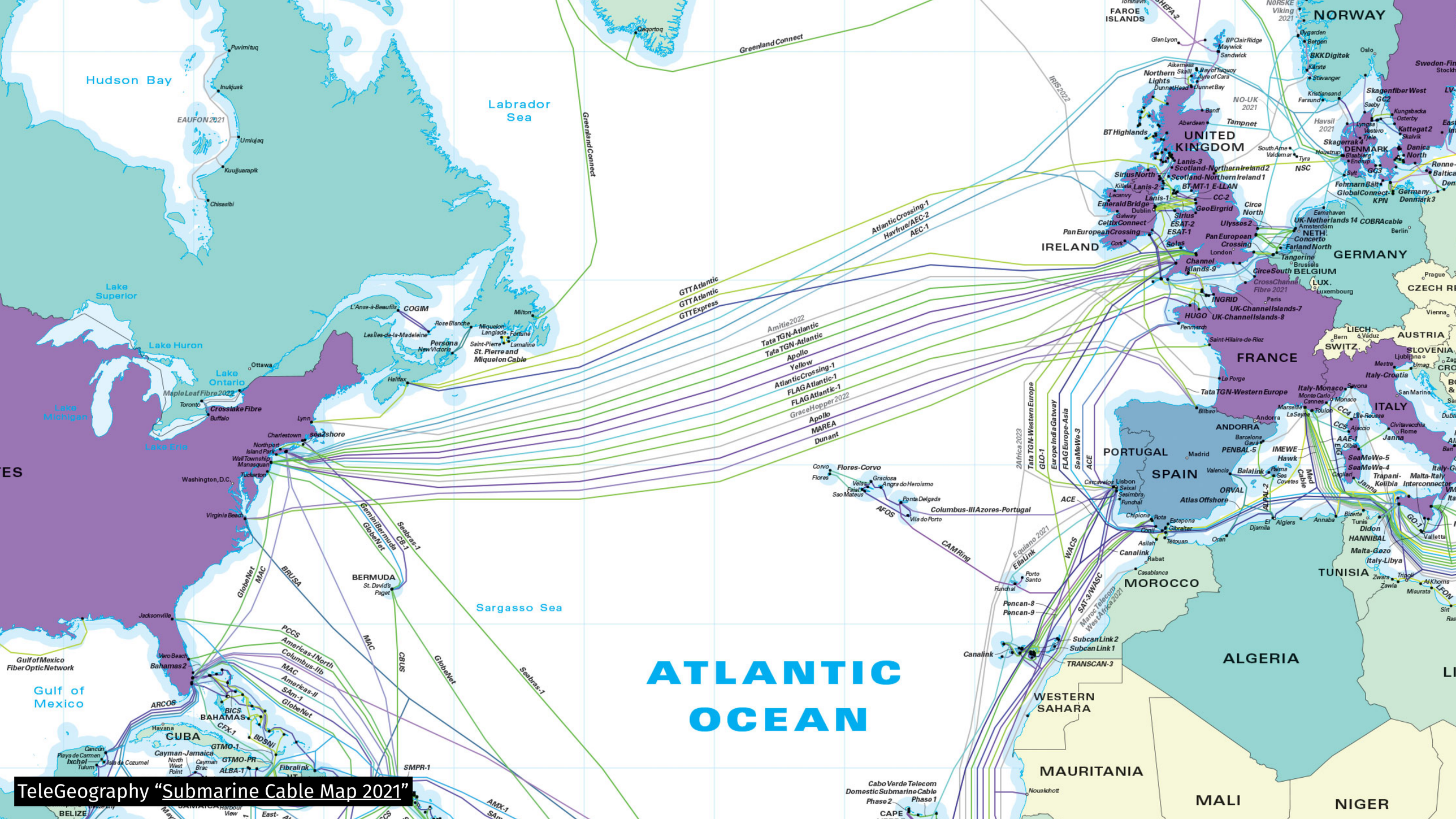
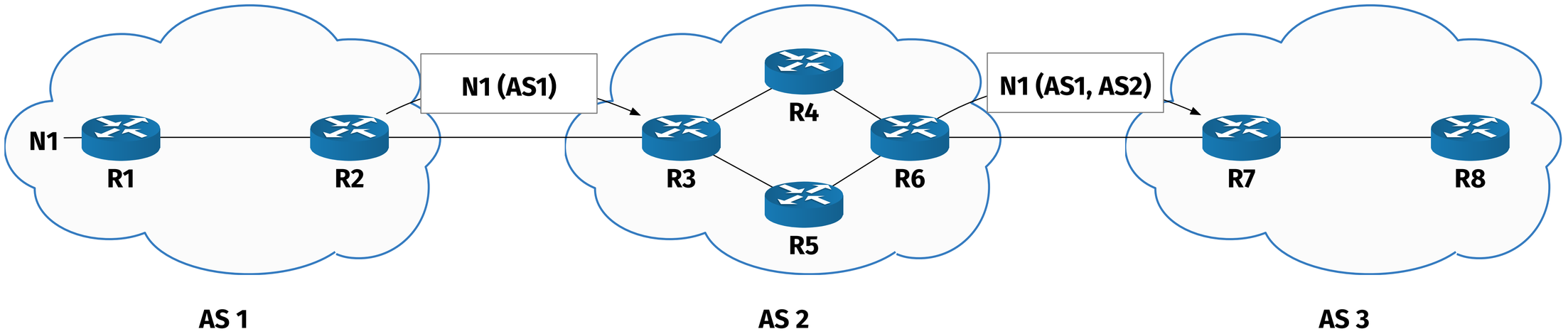
Sponsored by Telecom Egypt
B7 Smart Village, K28 Cairo-Alex Desert Road, Giza 12577, Egypt
www.te.eg ibu@te.eg



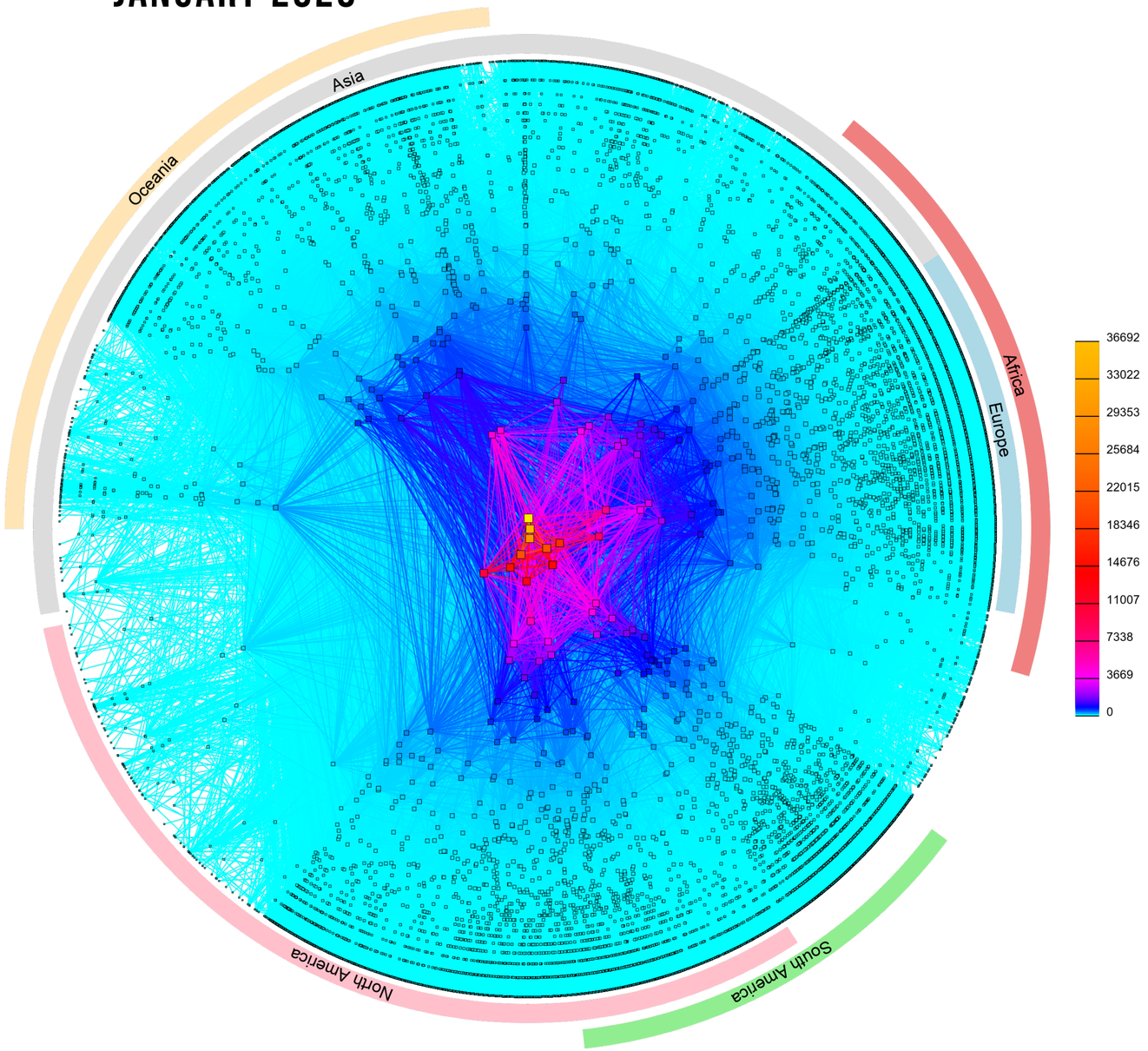

TeleGeography "Submarine Cable Map 2021"




TeleGeography "Submarine Cable Map 2021"


N1
R1
R2
N1 (AS1)
R3
R4
R5
R6
N1 (AS1, AS2)
R7
R8
AS 1
AS 2
AS 3

# CAIDA'S IPV4 AS CORE GRAPH
# JANUARY 2020




CAIDA "IPv4 and IPv6 AS Core"

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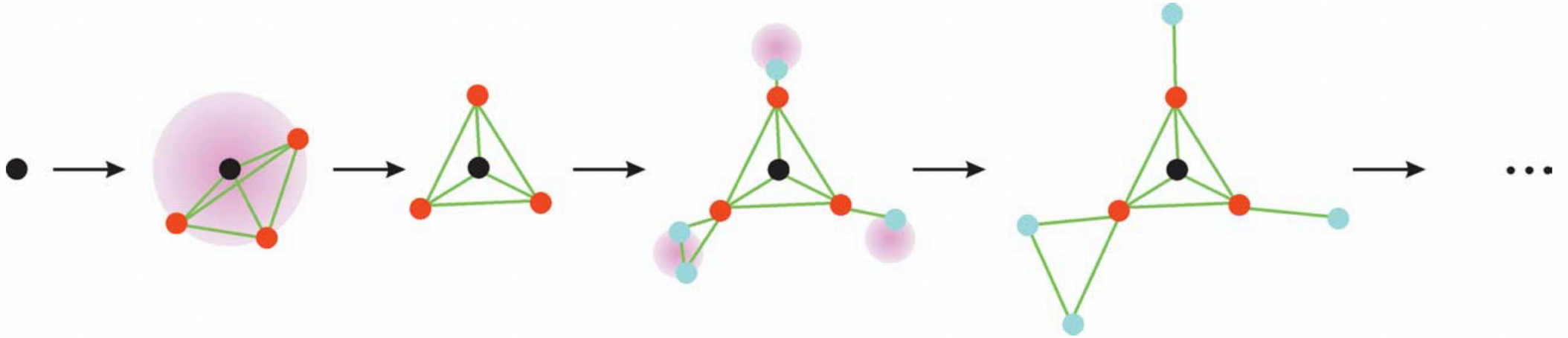
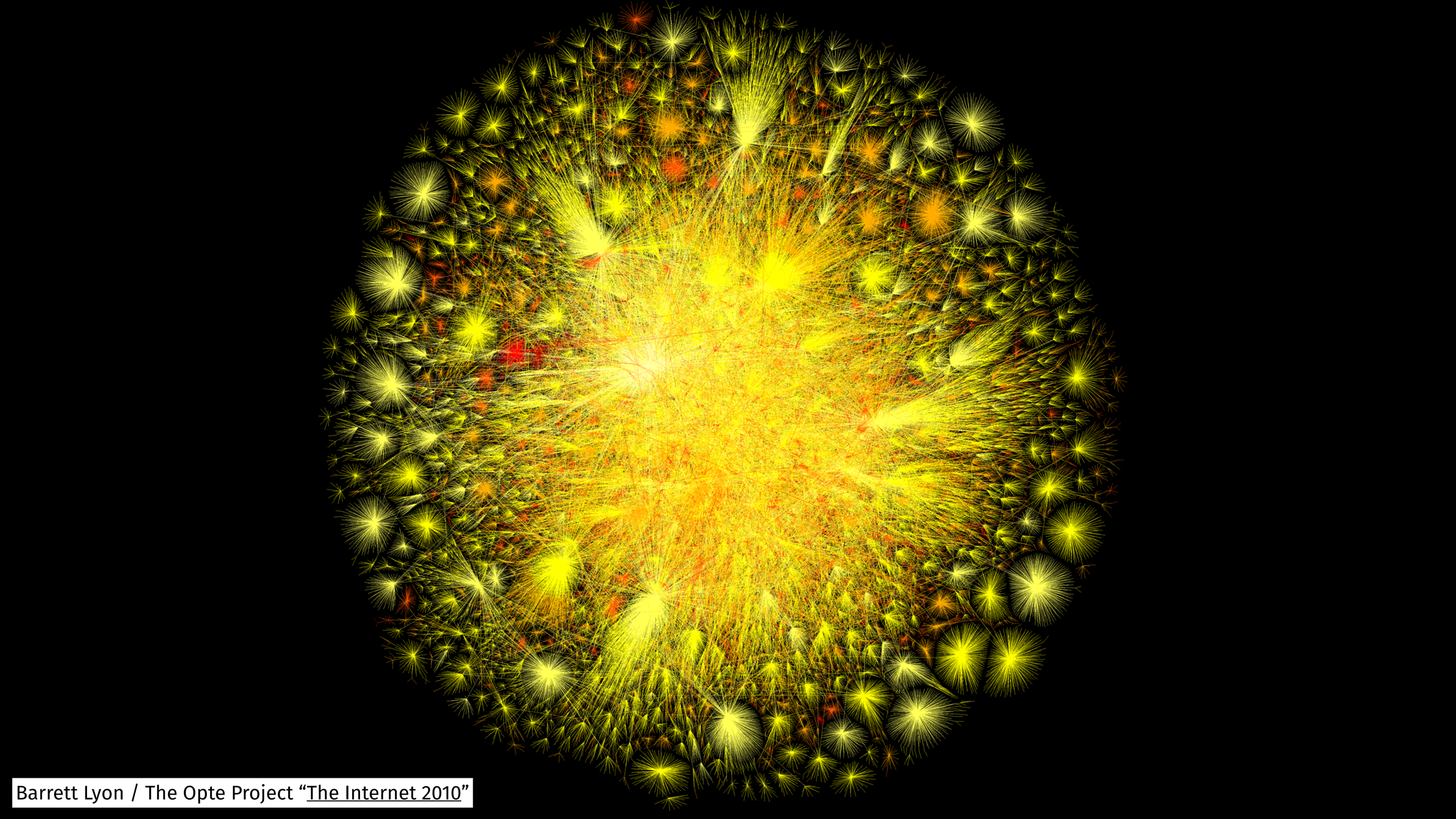
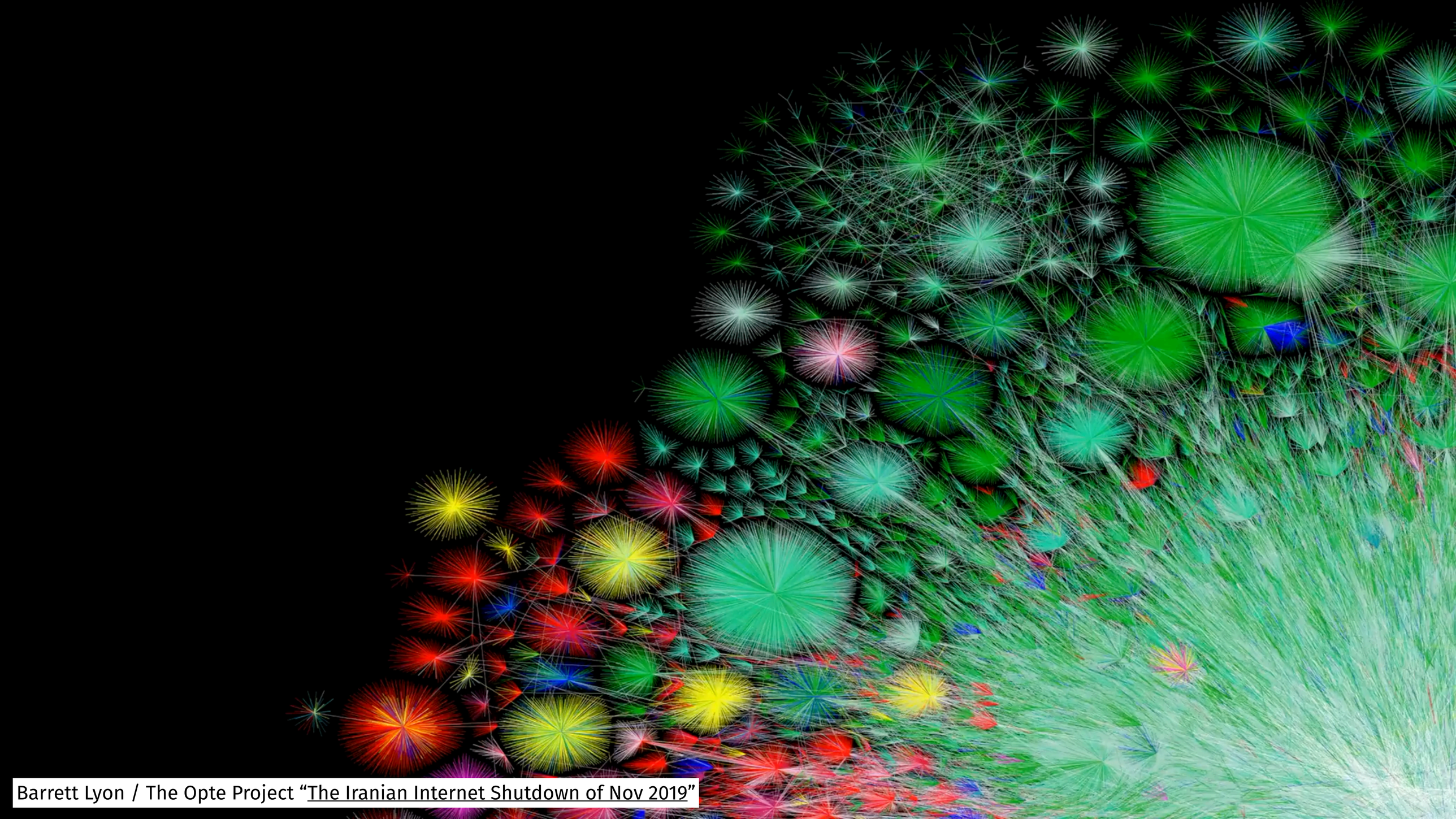


**Figure 1**. Successive iterations of the layout. Level one vertices (red circles) are placed randomly on a sphere around the root node (black circle). The system is allowed to iterate through time satisfying attractive and repulsive forces until at rest. Level two nodes (blue circles) are placed randomly on spheres directed away from the current layout. Again, the system is allowed to evolve through time till at rest. This process is iterated for the entire graph.

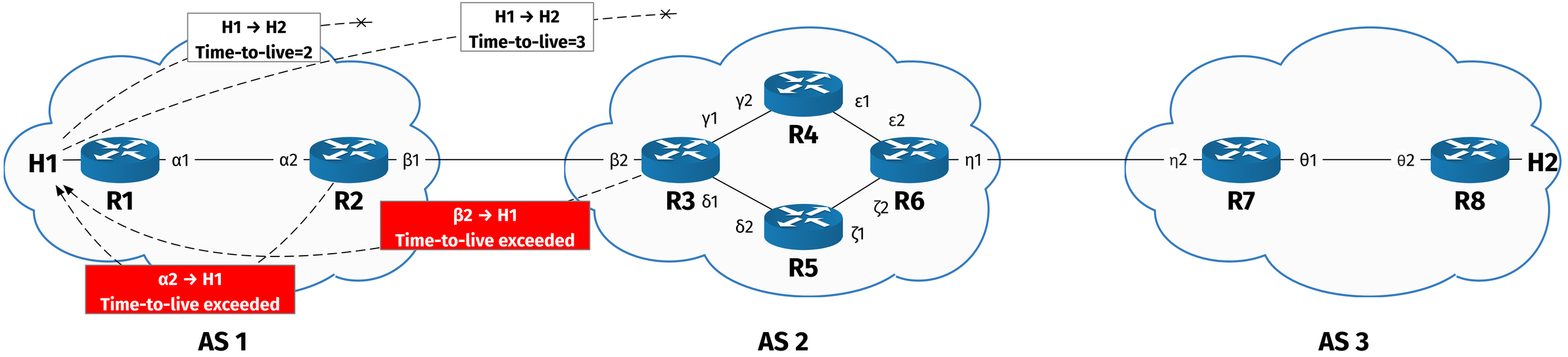
Alex T. Adai et al. "LGL: creating a map of protein function with an algorithm for visualizing very large biological networks"



Barrett Lyon / The Opte Project “The Internet 2010”



Barrett Lyon / The Opte Project “The Iranian Internet Shutdown of Nov 2019”


H1 → H2
Time-to-live=2
H1 → H2
Time-to-live=3
H1
α1
α2
β1
R1
R2
β2 → H1
Time-to-live exceeded
α2 → H1
Time-to-live exceeded
AS 1
γ1
γ2
ε1
ε2
R4
β2
R3
δ1
δ2
ζ2
R6
ζ1
R5
η1
AS 2
η2
θ1
θ2
H2
R7
R8
AS 3

Bill Cheswick et al. “Mapping and Visualizing the Internet”

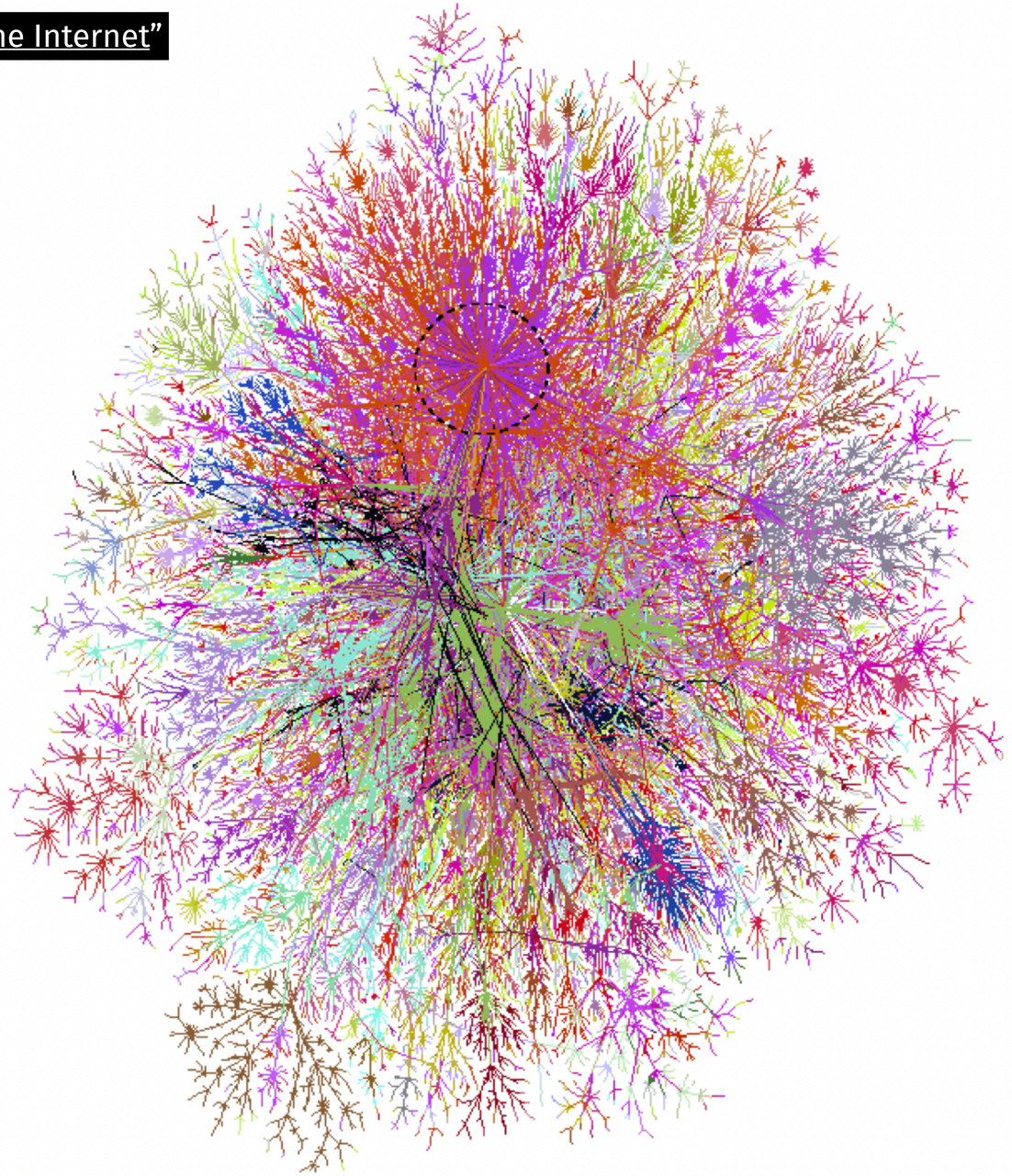
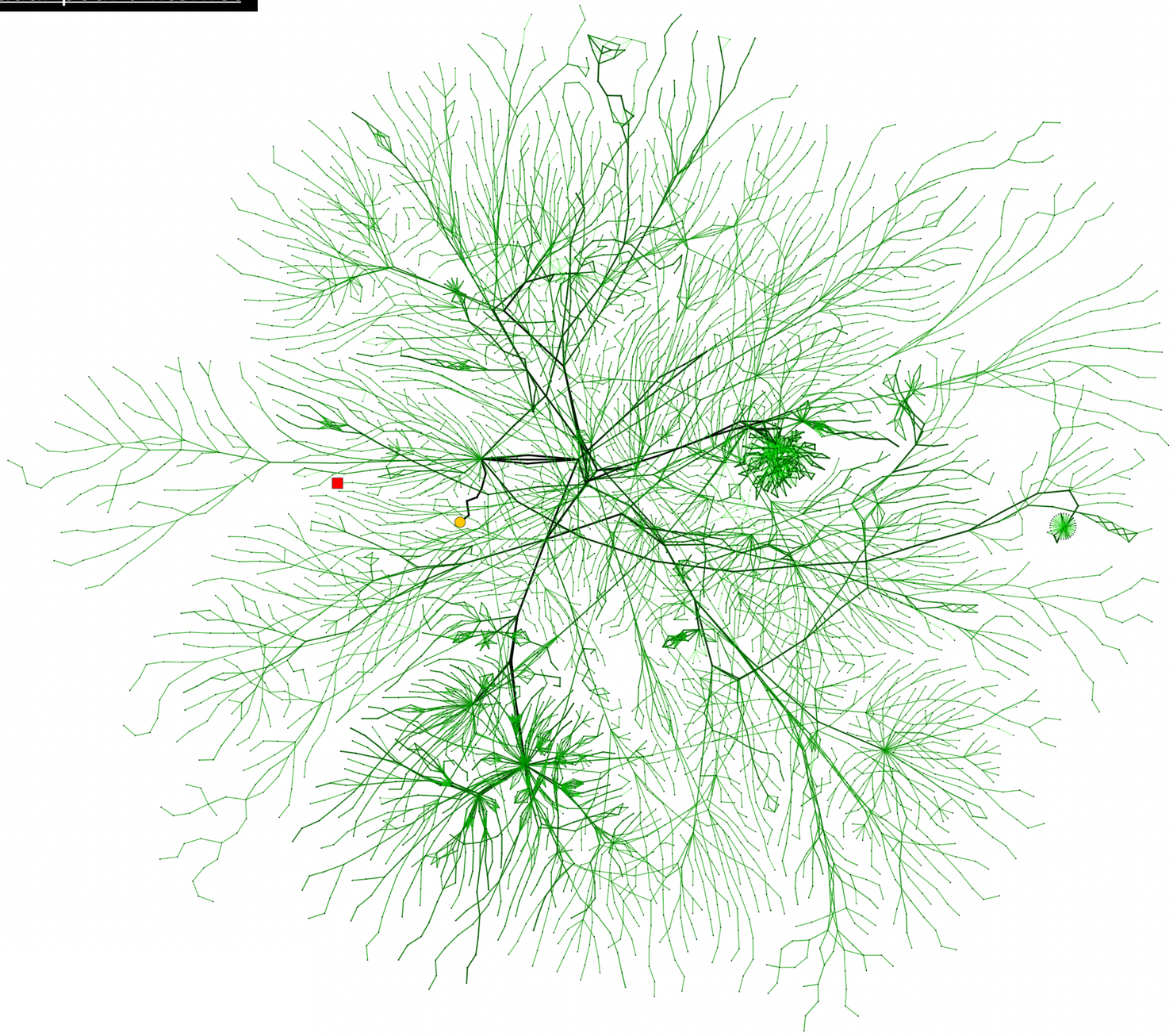
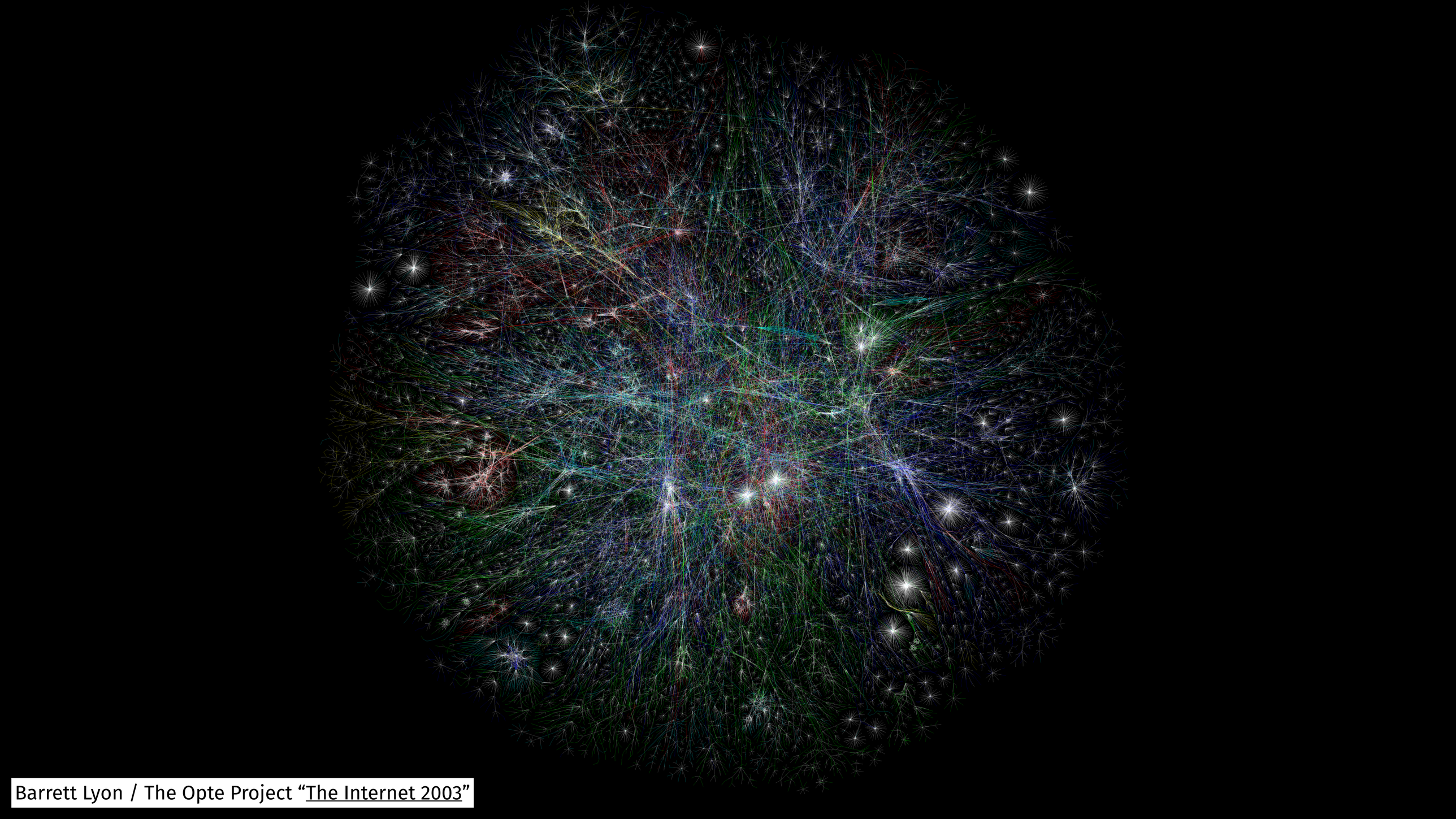


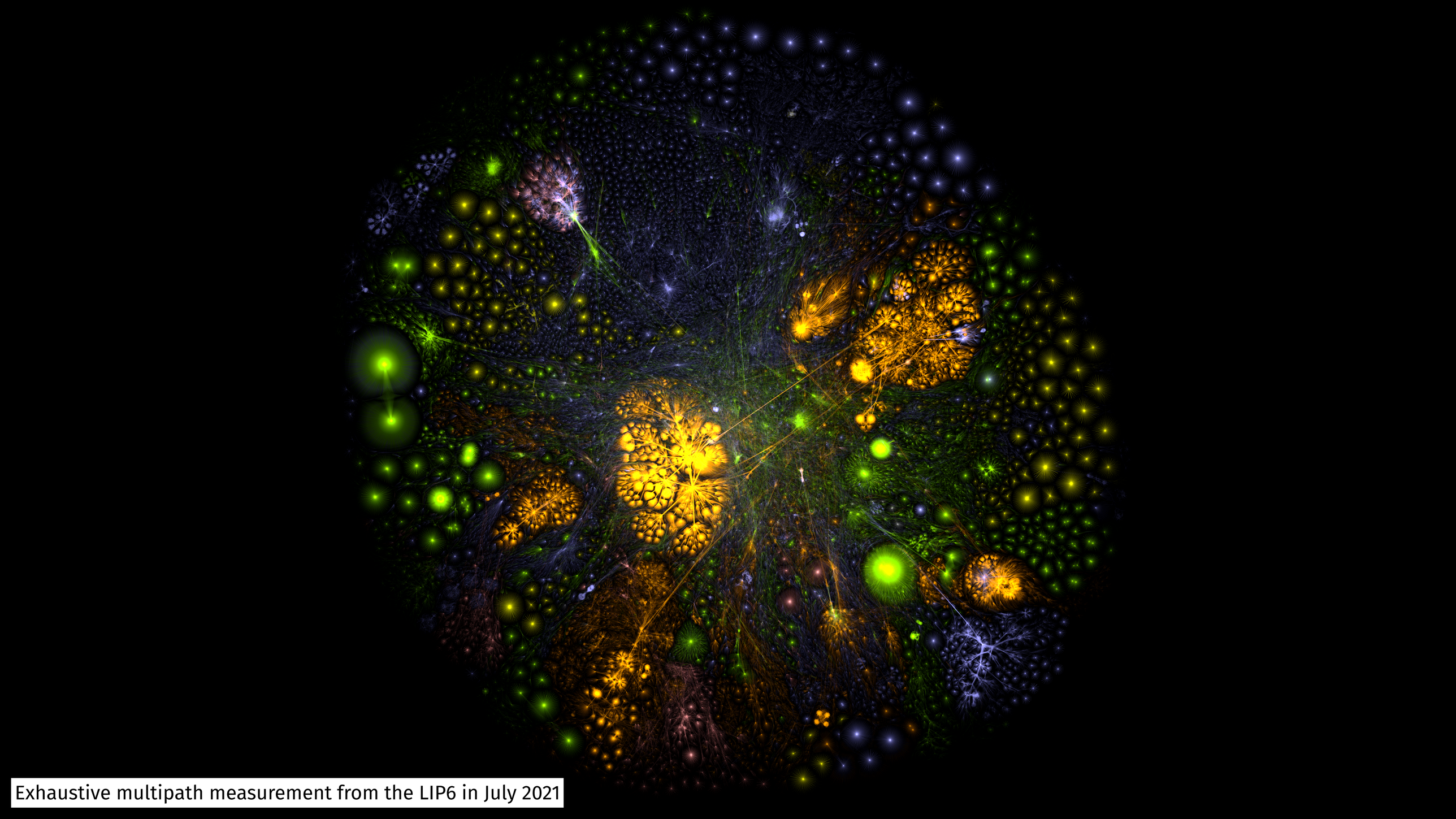
Figure 1: “Peacock-on-the-windshield” map from data taken in September 1998. The circled network is `cw.net`. Color versions of all figures are available at `http://www.cheswick.com/ches/map/mapfigs/`

Matthieu Latapy et al. “Vers un Radar pour l'Internet”

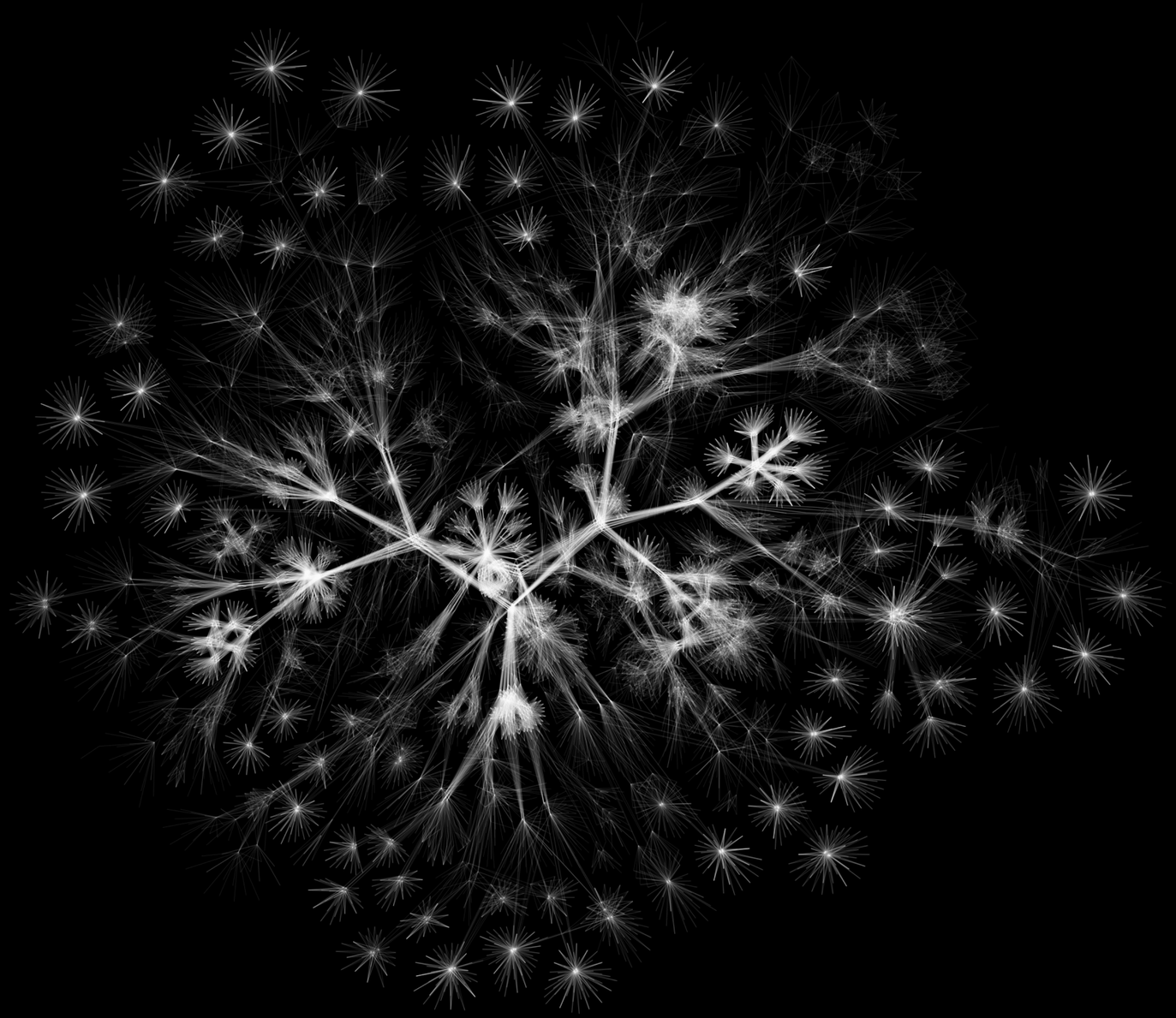




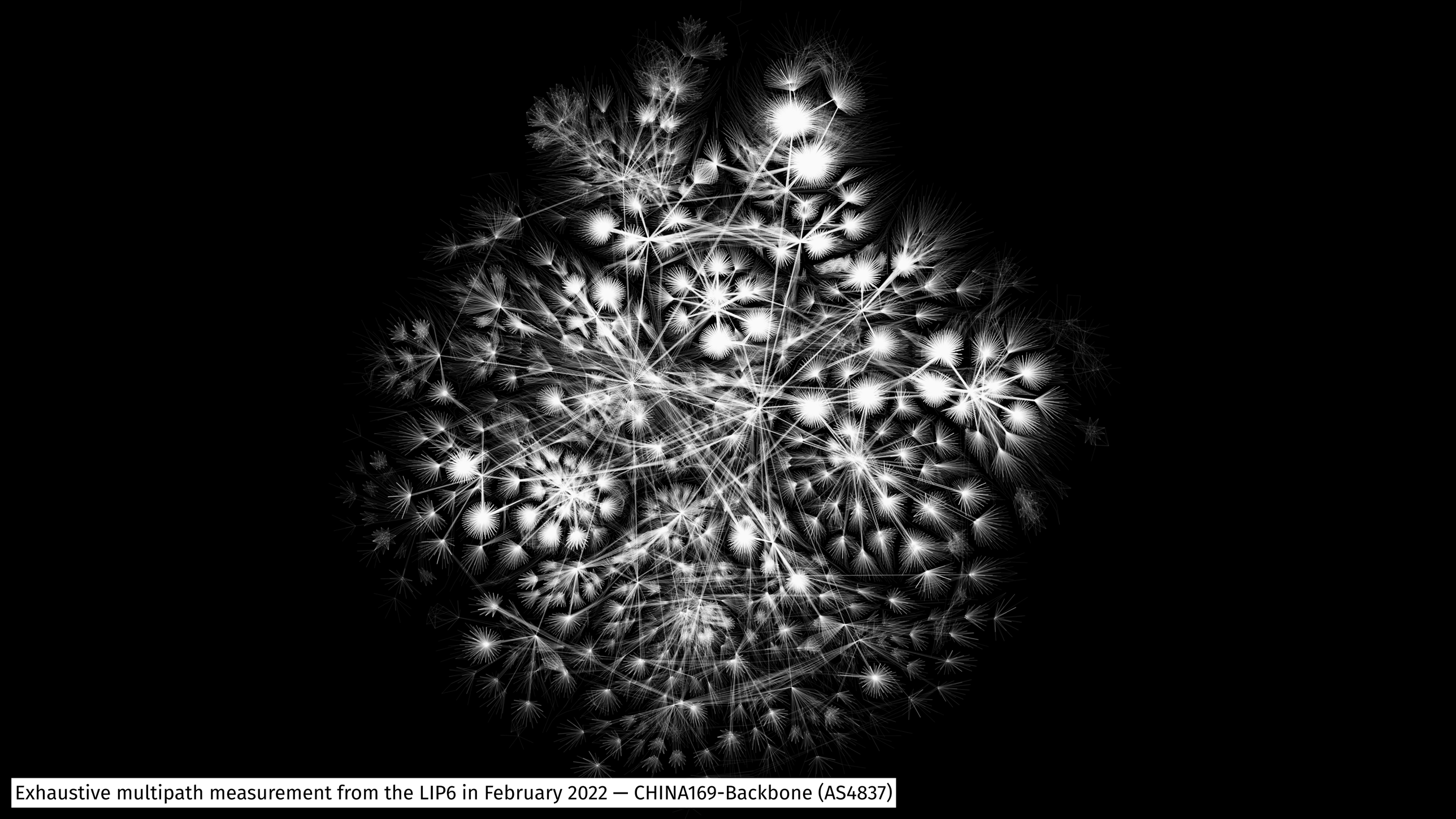
Barrett Lyon / The Opte Project “The Internet 2003”



Exhaustive multipath measurement from the LIP6 in July 2021



Exhaustive multipath measurement from the LIP6 in February 2022 — Google (AS15169)

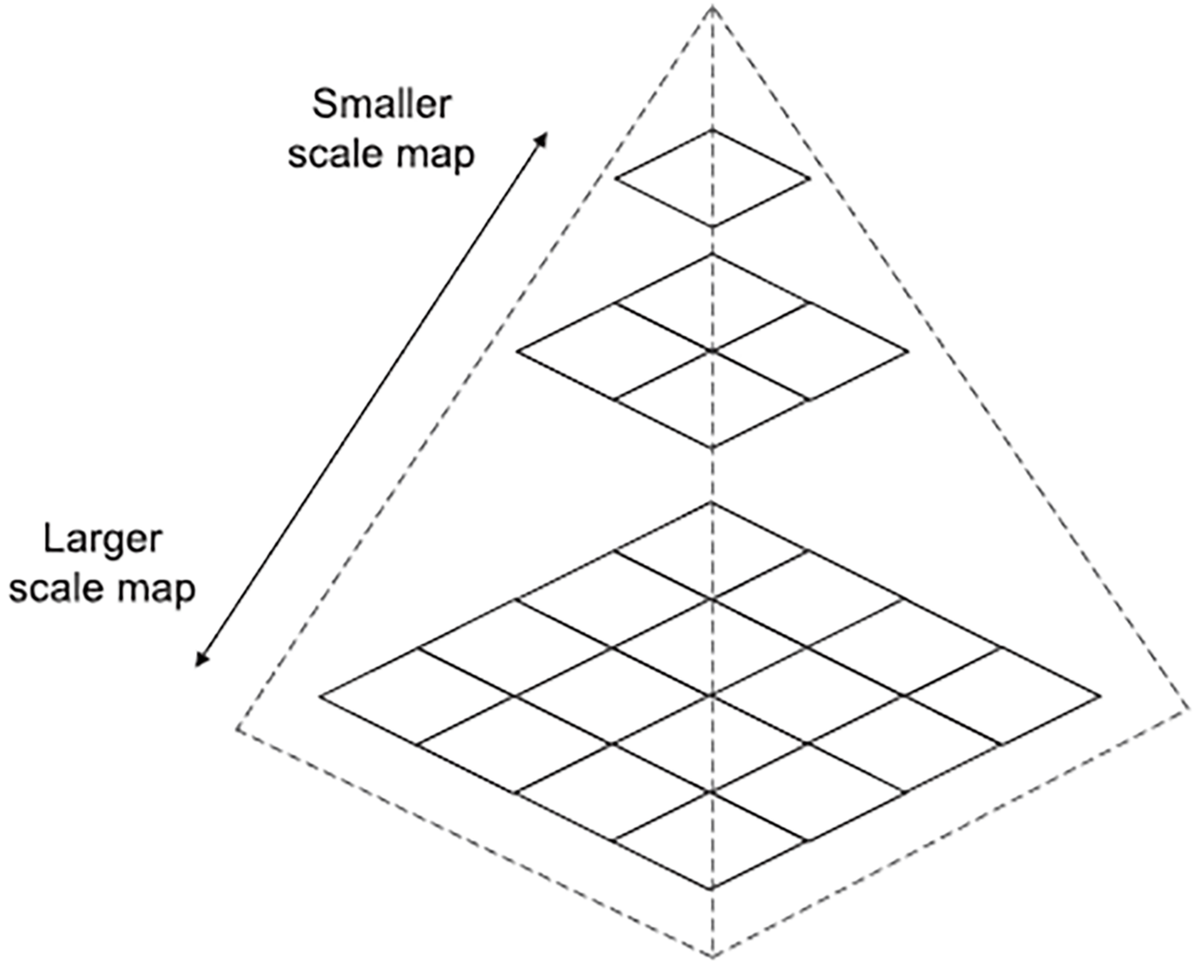


Exhaustive multipath measurement from the LIP6 in February 2022 — CHINA169-Backbone (AS4837)

Exhaustive multipath measurement from the LIP6 in February 2022 — Deutsche Telekom AG (AS3320)

# Adding interactivity

- Static images are fast to draw
- (Very) high-resolution images are inconvenient (memory requirements)
- How to show millions of edges in real-time?
- How to add information (e.g. AS name or link endpoints) without overloading the screen?
- Already solved for web maps (e.g. Google Maps)
- Reuse free & open-source cartography tools: MapLibre GL and Tippecanoe


Smaller
scale map
Larger
scale map

# Data pipeline

1. Compute links from traceroute measurements
    1. Exclude anonymous nodes
    2. Exclude prefixes with *reply amplification* or *routing loops*
    3. Exclude *unlikely* links
2. Extract the largest connected component
3. Compute the LGL layout
4. Augment the data with AS, RIR and facility information
5. Generate the tile set by dropping densest features at each zoom level

# Demo

# Future works

- Animate interactive graphs over time
- Use RTT (round-trip time) information
  - Delay-based layout?
  - Color edges by RTT from source
- Geo-based layout
- Router-level graph
- Include data from multiple vantage points
- Include other data sources (CAIDA Ark, M-Lab, RIPE Atlas)
- Highlight paths from the source

# Thanks!