SC4024/CZ4124
Data Visualization

Assistant Professor WANG Yong

yong-wang@ntu.edu.sg

CCDS, Nanyang Technological University

1

Chapter 11.1
Hierarchical Data (Tree) Visualization

2

Outline

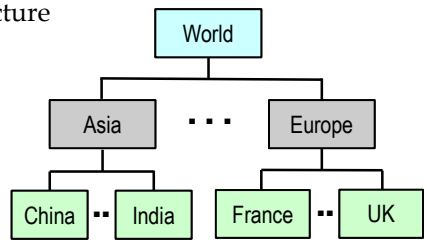
- What is hierarchical data?
- What are the hierarchical data visualization (a.k.a., Tree Visualization) methods?
  - Node-link (tree) diagrams
  - Indented trees
  - Layered (adjacency) diagrams
  - Enclosure diagrams

3

3

Hierarchical Data

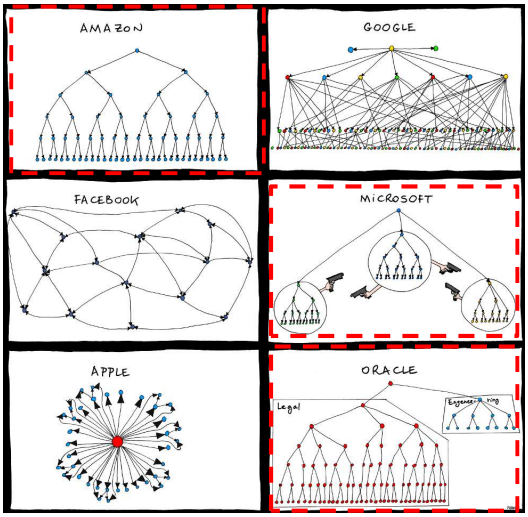
- Hierarchical data represent the **hierarchical relationship** between objects/entities, where **the attributes** associated with objects/entities are often considered as well.
- As an example, **countries** (e.g. China, India, France, UK, etc) are a subset of continents (e.g. Asia, Europe, etc).
- More Examples:
  - Hierarchical organizational structure
  - Information organization
    - File directories
    - Development of species
  - Logical connections
    - Decision tree



4

4

Hierarchical Data: Organizational Chart of IT Companies



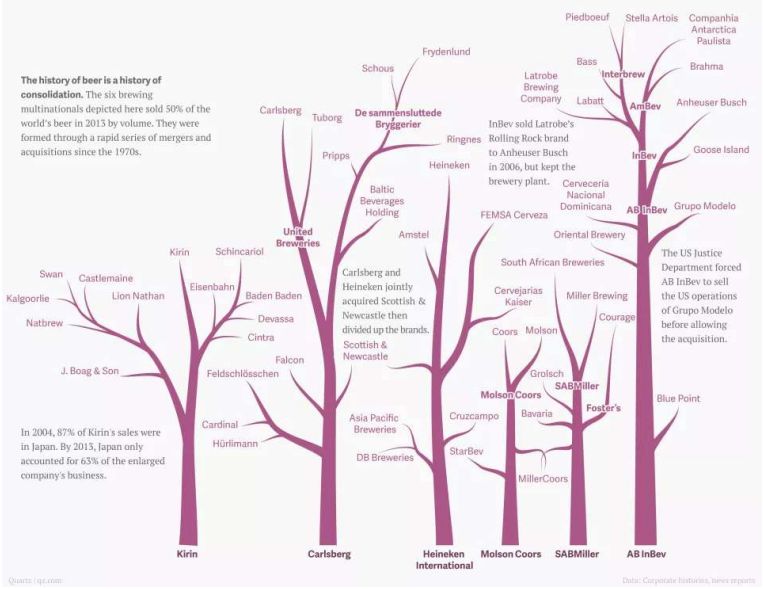
Hierarchical data are intrinsically in a **tree-like** structure.

https://ritholtz.com/2013/07/organizational-charts-of-amazon-apple-facebook-microsoft/

5

5

Hierarchical Data: Beer Family Tree



https://flowingdata.com/2014/10/02/beer-family-tree/

6

6

7

Hierarchical Data Visualization

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

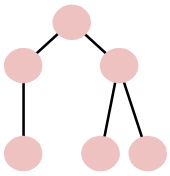
- Node-link (tree) diagrams
- Indented trees
- Layered (adjacency) diagrams
- Enclosure diagrams
  - Treemap
  - Circle packing layout

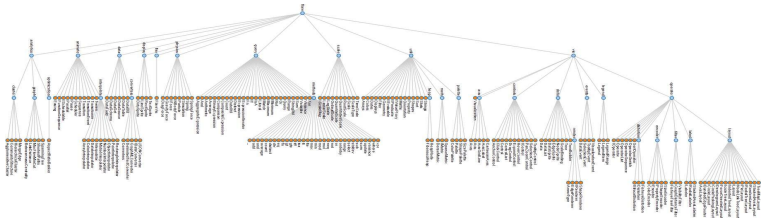
8

8

Node-link Tree Diagrams

- Nodes are distributed in space, connected by straight or curved lines
- Typical approach is to use 2D space to break apart breadth and depth
- Often, space is used to communicate hierarchical orientation





9

9

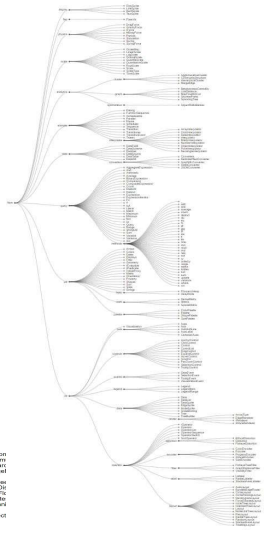
Node-link Tree Diagrams

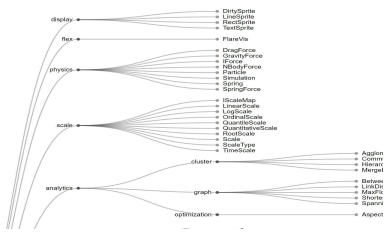
- Tidy Tree

  - Implements the Reingold-Tilford algorithm for efficient, tidy arrangement of layered nodes

  - Depth of nodes computed by distance from the root

  - Integrated into D3





https://observablehq.com/@d3/tree-component

10

10

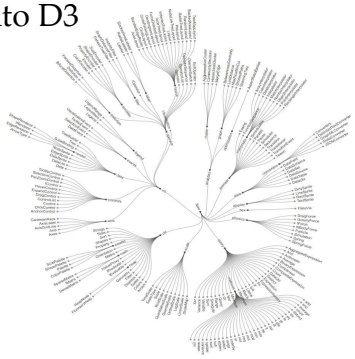
Node-link Tree Diagrams

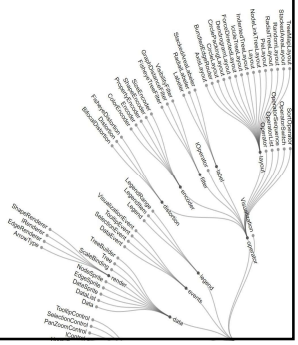
- Radial Tidy Tree

  - A radial layout is based on a polar rather than Cartesian coordinates

  - It has a pleasing aesthetic, and uses space more efficiently

  - Integrated into D3





https://observablehq.com/@d3/radial-tree-component

11

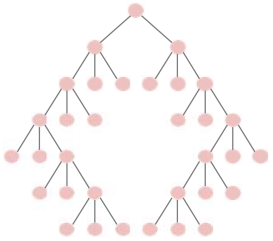
Node-link Tree Diagrams

- Reingold-Tilford algorithm for drawing node-link diagrams

  - Bottom-up recursive approach: Repeatedly divide space by leaf count

  - For each parent, make sure subtrees are drawn

  - Make smarter use of space
    + Maximize density and symmetry
    + Clearly encode depth level
    + No edge crossings
    + Pack subtrees as closely as possible
    + Centers parent over subtrees



https://williamyaoh.com/posts/2023-04-22-drawing-trees-functionally.html

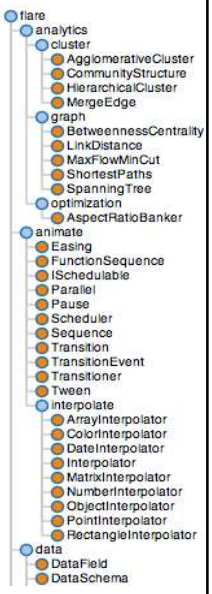
12

12

Indented Trees

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

- Indentation is used to show parent-child relationships
- It is easy to implement and intuitive to understand
- But much scrolling is often needed in big data browsing and may lose the context



The directory structure of Flare package

http://hci.stanford.edu/jheer/files/zoo/

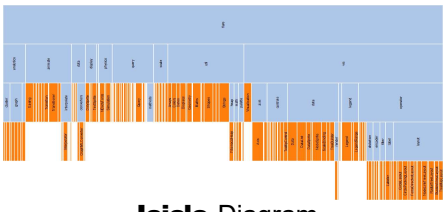
13

13

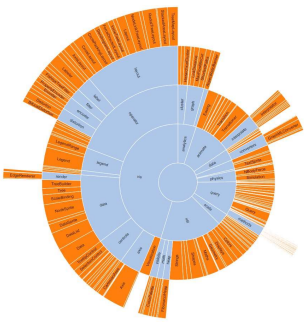
Layered (adjacency) Diagrams

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

- They are space-filling variants of node-link diagrams, such as **icicle diagram** and **Sunburst diagram**
- Nodes drawn as solid areas (arcs or bars)
- Placement relative to adjacent nodes reveals place in hierarchy
  - Root node at the top/center
  - Leaf nodes at the bottom/outside



Icicle Diagram



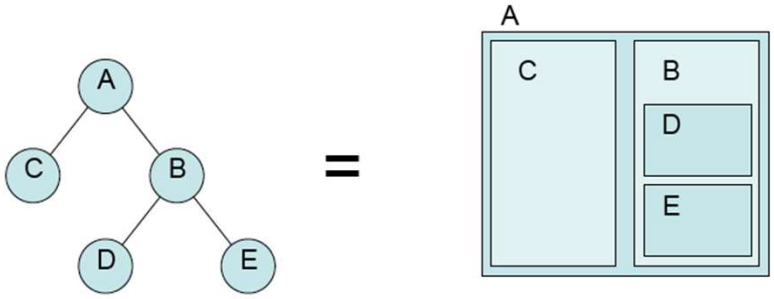
Sunburst Diagram

14

14

Enclosure Diagrams or Treemaps

- Encodes tree structure using *spatial enclosure*
  - Enclosure indicates hierarchy
- Benefits:
  - Provides single view of entire tree
  - Easier to spot small / large nodes

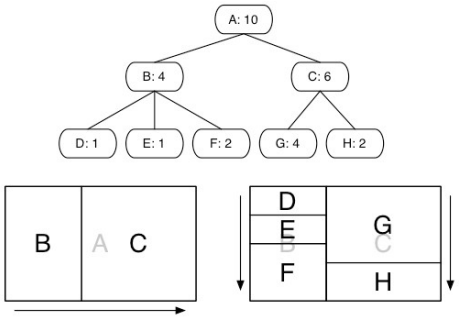


15

15

Enclosure Diagrams or Treemaps

- Assume that each leaf node has a size-related attribute (e.g., size of the file); size of parent nodes is the sum of its children's sizes
- Recursively slice and dice a rectangle in different directions to represent a (potentially large) hierarchy



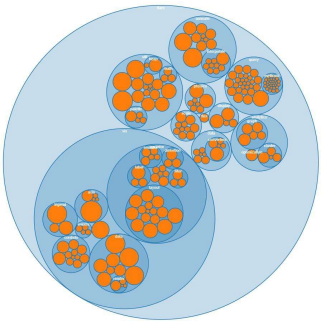
Source: http://eagereyes.org/Techniques/Treemaps.html

16

16

Enclosure Diagrams or Treemaps

Enclosure diagram (treemap)



Circle-packing layout

Question: Is it easy for you to visual identify the ***depth*** of the tree?

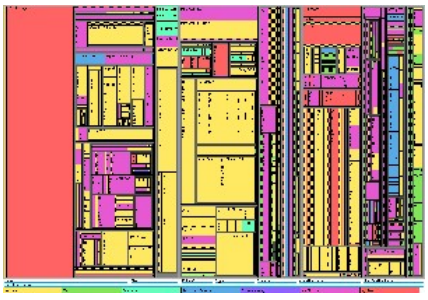
17

17

Father of Treemap

- Treemap was first introduced in 1991
- It was first used to visualize storage usage in a hard disk
- For more historical development of treemap: http://www.cs.umd.edu/hcil/treemap-history/

Ben Shneiderman



18

18

Slice-and-dice Treemap

- Ben Shneiderman proposed the slice-and-dice Treemap in 1991
- Layout method:
  - Recursive subdivision
  - Root is the largest rectangle
  - Size of child nodes are assigned according to their weights
  - Subdivide children nodes

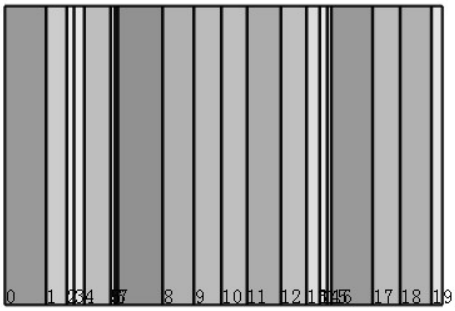
Tree visualization with treemaps: a 2-d space-filling approach. Shneiderman, B. March 1991. *ACM Transactions on Graphics*, vol. 11, 1 (Jan. 1992) 92-99. HCIL-91-03, CS-TR-2645, CAR-TR-548

19

19

Problems of Slice-and-dice Treemap

- Simple slice-and-dice subdivision method results in thin and long rectangles
- It would be difficult to interact with nodes

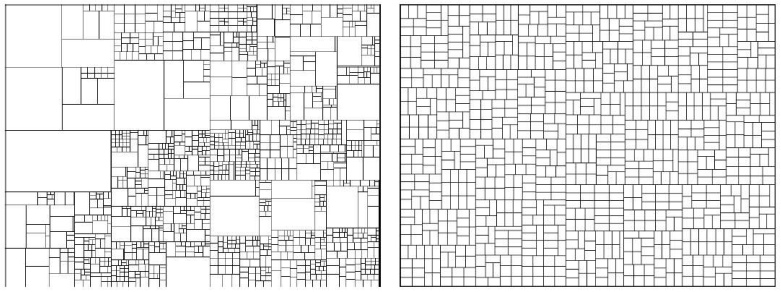


20

20

Squarified Treemap

- Optimize the placement of nodes within a level to make them as square as possible



(a) File system (b) Organization

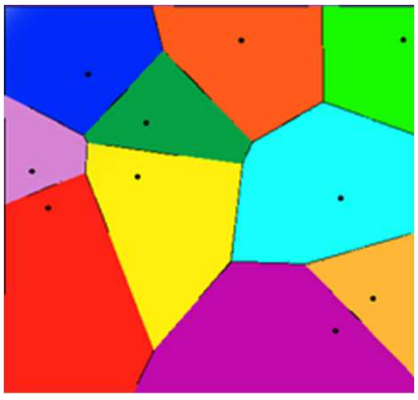
Source: http://www.win.tue.nl/~vanwijk/stm.pdf

21

21

Variant of Treemap: Voronoi Treemaps

- Voronoi treemaps visualize hierarchical data by recursively partitioning convex polygons using weighted centroidal Voronoi diagrams



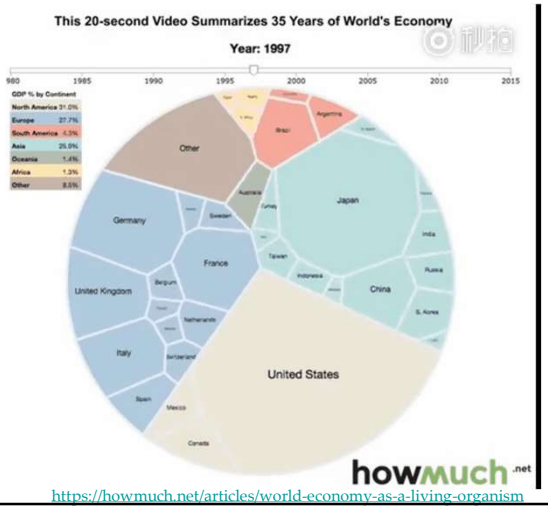
https://en.wikipedia.org/wiki/Voronoi_diagram

22

22

Variant of Treemap: Voronoi Treemap

- Example: Use animated Voronoi Treemap to summarize 35 Years of World's Economy



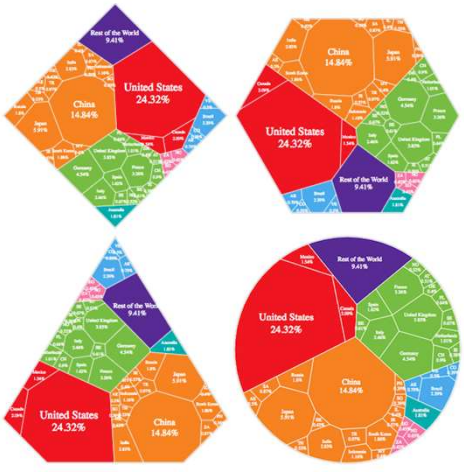
https://howmuch.net/articles/world-economy-as-a-living-organism

23

23

Variant of Treemap: Voronoi Treemap

- Voronoi treemap in D3

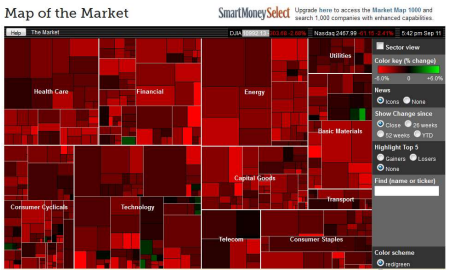


https://github.com/Kcnarf/d3-voronoi-treemap

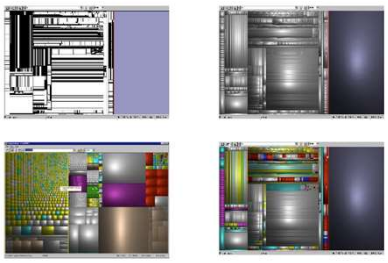
24

24

Treemap Applications



Stock Market



Disk Browser

Business Sale Data Analytics

Source: http://www.smartmoney.com/map-of-the-market/?link=SM_topnav_invest
http://www.hivegroup.com/solutions/demos/salesforce.html

25

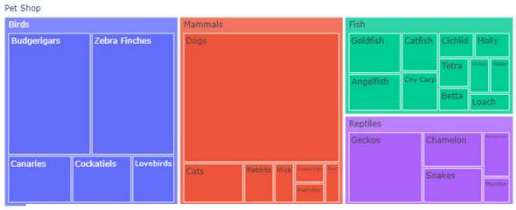
25

Treemap Implementation with Plotly

- The **treemap** method from the Python package **Plotly** can be used.

```
import plotly.express as px                # import Plotly Express
L1 = 'Species'                             # top hierarchy – Species
L2 = 'Animal Name'                         # next hierarchy – Animal Name
Fig = px.treemap(Data, path=[px.Constant('Pet Shop'), L1, L2], # call treemap
                 values='No. in Shop')  # map rectangle area to no. in pet shop
```

L1	L2	Area
Species	Animal Name	No. in Shop
Birds	Zebra Finches	50
Birds	Canaries	15
:	:	
Mammals	Dogs	100
:		
Fish	Goldfish	12
:		
Reptiles	Monitor	2



Treemap of Animal Inventory (No. in Shop) encoded in the Area

Plotly, Treemap - https://plotly.com/python/treemaps/

26

26

Summary

- Hierarchical data represent the **hierarchical relationship** between objects/entities, where **the attributes** associated with objects/entities are often considered as well.

- We have introduced four major types of **hierarchical data visualization** (a.k.a., **tree visualization**) techniques
  - Node-link (tree) diagrams
  - Indented trees
  - Layered (adjacency) diagrams
  - Enclosure diagrams

27

27

Questions?

Thank You!

28