D3 Tutorial

Hierarchical Layouts

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Hierarchical Layouts

- D3 has a number of hierarchical layouts to help with visualizing hierarchies or trees
- We'll look at the *tree*, *cluster*, *treemap*, *pack* and *partition* layouts
  - *treemap*, *pack* and *partition* are designed to lay out hierarchies where the nodes have an associated numeric value (e.g. population, revenue etc.).

Hierarchy – d3.hierarchy()

- D3 requires the hierarchical data to be in the form of a *d3.hierarchy* object
  - We can transform our data format to *d3.hierarchy* object by d3.hierarchy(*data*, *children*) function
    - Returns the root node of the *d3.hierarchy* object
  - For example, we have a pedigree of Eve's family right
    - We can transform it to a *d3.hierarchy* object by

```
var root = d3.hierarchy(data, function(d) {
        return d.children;
    });
```

    - The second parameter is a function that transmits the information of children
      - The *key* characters (here, "children") must be the same as the data

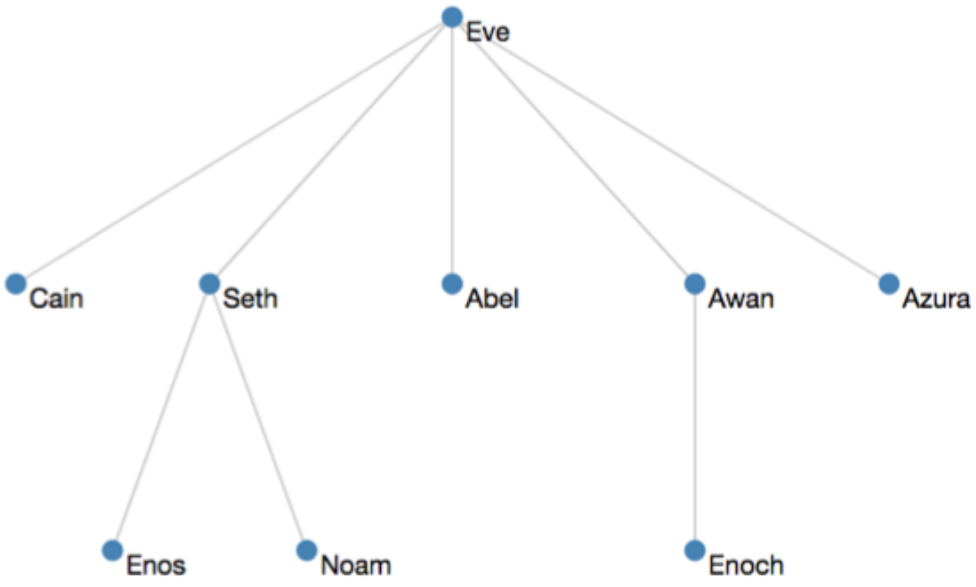
```
var data = {
  "name": "Eve",
  "children": [
    {
      "name": "Cain"
    },
    {
      "name": "Seth",
      "children": [
        {
          "name": "Enos"
        },
        {
          "name": "Noam"
        }
      ]
    },
    {
      "name": "Abel"
    },
    {
      "name": "Awan",
      "children": [
        {
          "name": "Enoch"
        }
      ]
    },
    {
      "name": "Azura"
    }
  ]
};
```

Hierarchy – d3.hierarchy()

- d3.hierarchy() function will construct a new nested hierarchical structure to store our data

```
▼ vo {data: {…}, height: 2, depth: 0, parent: null, children: Array(5)}
  ▶ children: (5) [vo, vo, vo, vo, vo]
  ▶ data: {name: "Eve", children: Array(5)}
    depth: 0
    height: 2
    parent: null
  ▶ __proto__: Object
```

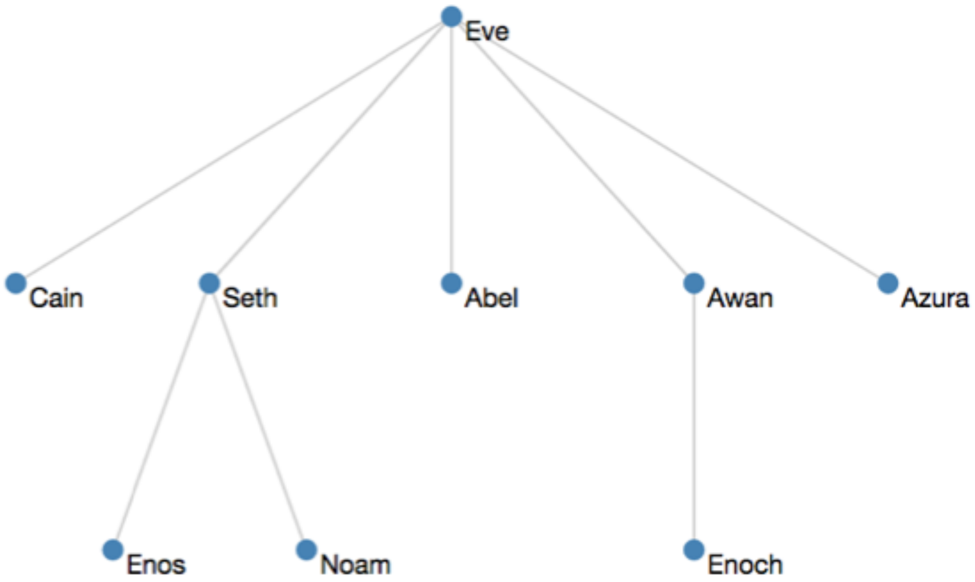
- Also, the d3.hierarchy() will compute *depth* and *height* of this node in this tree structure



Tree Layout – Tree Generator: d3.tree()

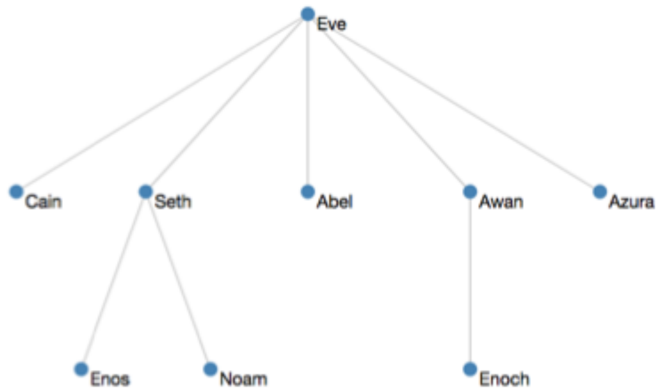
- The tree layout arranges the nodes of a hierarchy in a tree-like arrangement
  - Takes the size of screen
  - Computes *x* and *y* attributes for each node

```
var treeLayout = d3.tree()
  .size([width, height]);

treeLayout(root);
```



Tree Layout – Draw nodes of a tree

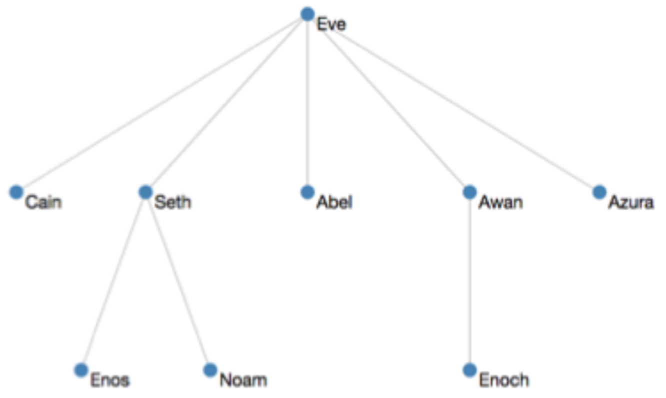
- Next, we draw all the nodes in the tree
  - We need an array of all the nodes
- *node*.descendants() function
  - Returns the array of descendant nodes, starting with this node, then followed by each child in topological order
- Then, create *circle* tags to draw nodes by computed *x* and *y* attributes




```
var allNodes = root.descendants();
d3.select('svg g.nodes')
  .selectAll('circle.node')
  .data(allNodes)
  .enter()
  .append('circle')
  .classed('node', true)
  .attr('cx', function(d) {
    return d.x;
  })
  .attr('cy', function(d) {
    return d.y;
  })
  .attr('r', 4);
```

Tree Layout – Draw links of a tree

- We draw links in the tree
- *node*.links()
  - Returns an array of links for this *node* (and its *descendants*), where each *link* is an object that defines *source* and *target* properties.
  - The *source* of each link is the parent node, and the *target* is a child node.

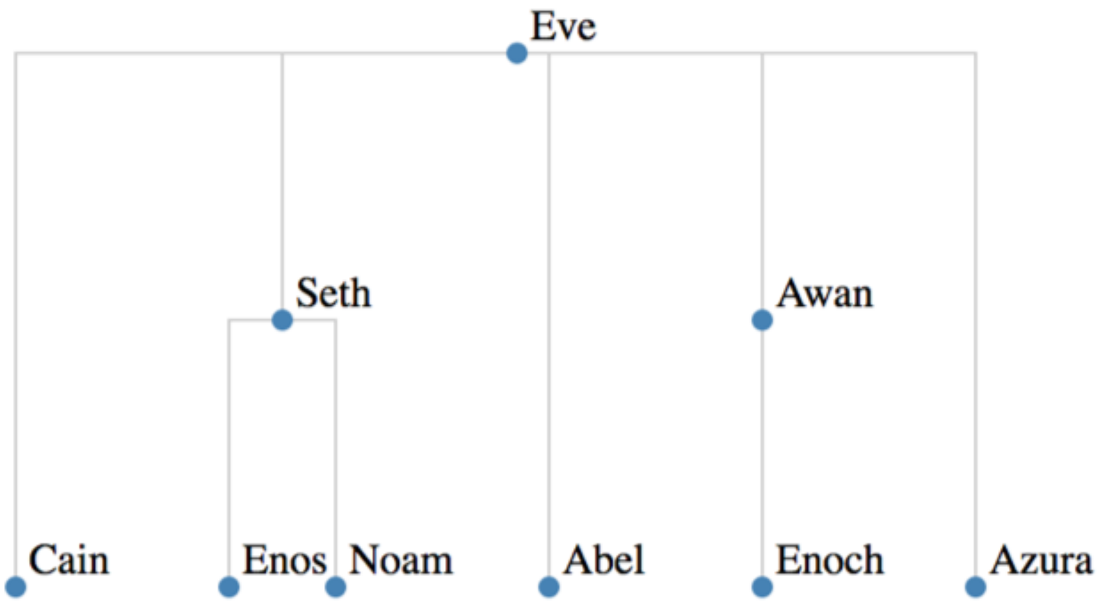



```
var allLinks = root.links();
d3.select('svg g.links')
  .selectAll('line.link')
  .data(allLinks)
  .enter()
  .append('line')
  .classed('link', true)
  .attr('x1', function(d) {return d.source.x;})
  .attr('y1', function(d) {return d.source.y;})
  .attr('x2', function(d) {return d.target.x;})
  .attr('y2', function(d) {return d.target.y;});
```

Cluster Layout

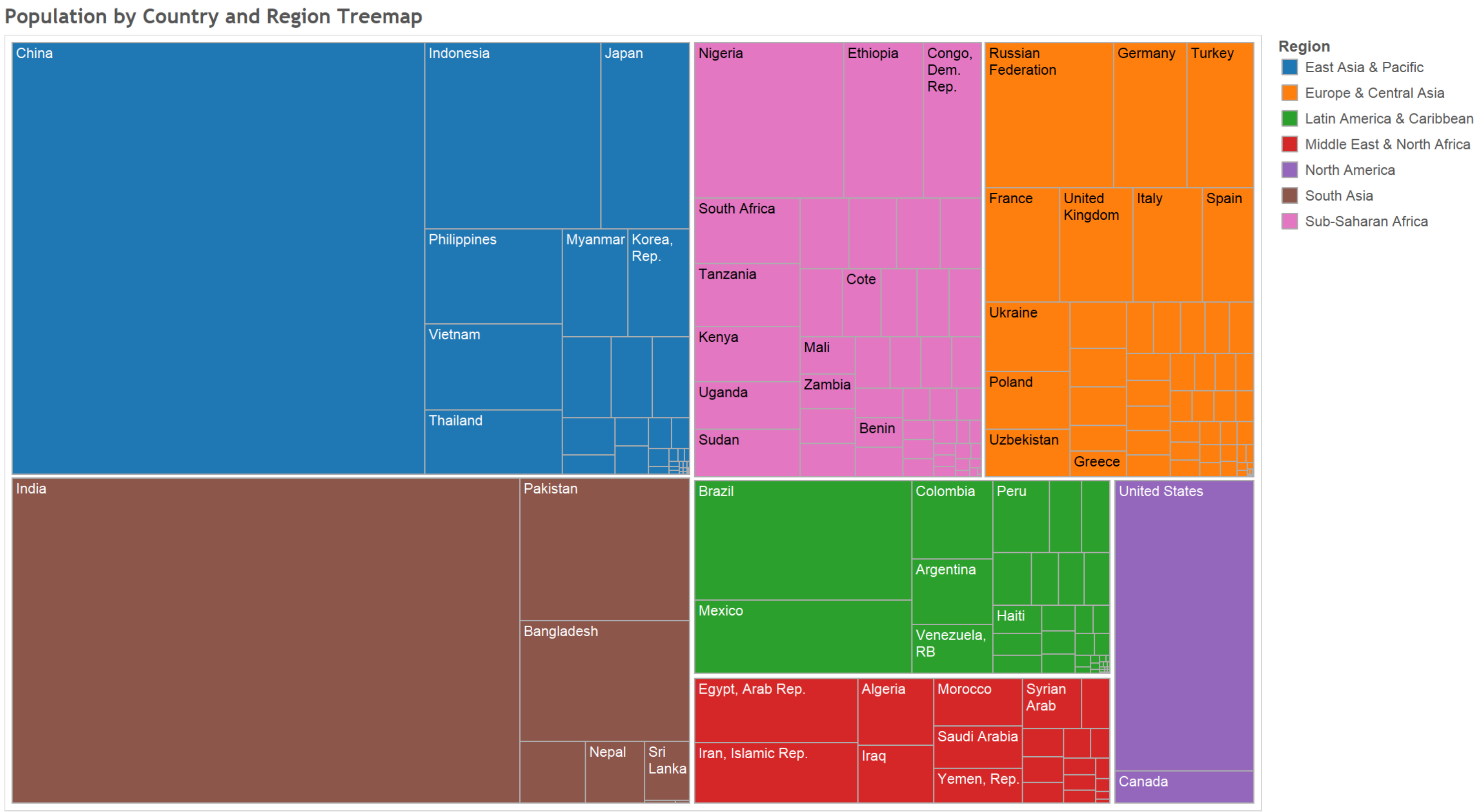
- The cluster layout is very similar to the tree layout
- The main difference being **all leaf nodes are placed at the same depth**.
- Codes are also similar
  - Change the layout generator from d3.tree() to **d3.cluster()**

```
var clusterLayout = d3.cluster()
  .size([width, height]);

clusterLayout(root);
```



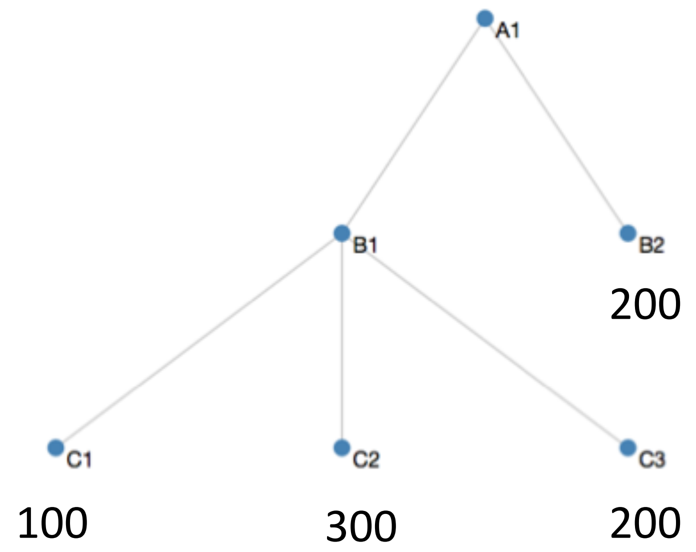
Treemap Layout

- Treemaps can visually represent hierarchies where each item has an associated value
- For example, we can think of country population data as a hierarchy
  - The first level represents the region
  - The next level represents each country.
  - A treemap will represent each country as a rectangle (sized proportionally to the population) and group each region together



Treemap Layout – Create a treemap

- Data
  - A fake hierarchical data
  - Each leaf node has a quantity value (e.g. population or revenue)




```
var data = {
  "name": "A1",
  "children": [
    {
      "name": "B1",
      "children": [
        {
          "name": "C1",
          "value": 100
        },
        {
          "name": "C2",
          "value": 300
        },
        {
          "name": "C3",
          "value": 200
        }
      ]
    },
    {
      "name": "B2",
      "value": 200
    }
  ]
};
```

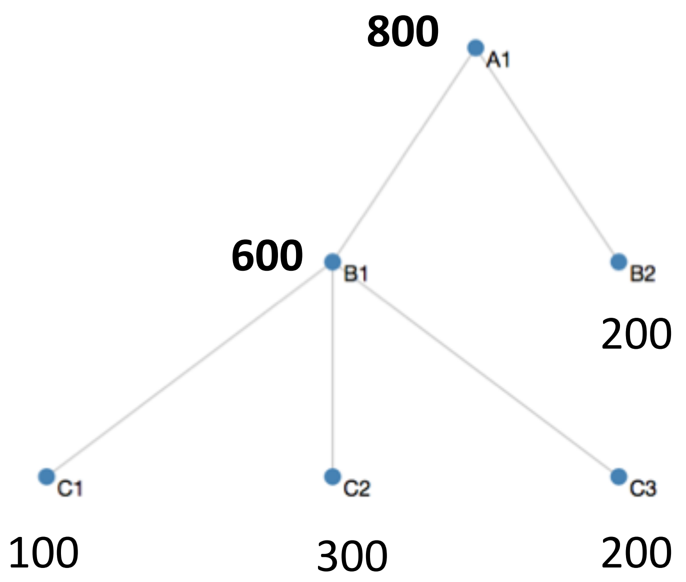
Treemap Layout – Create a treemap

- Construct the hierarchy structure

```
var rootNode = d3.hierarchy(data);
```

- Calculate values of parents
  - Equals to sum of children's values
  - *node*.sum() can calculates the sums automatically

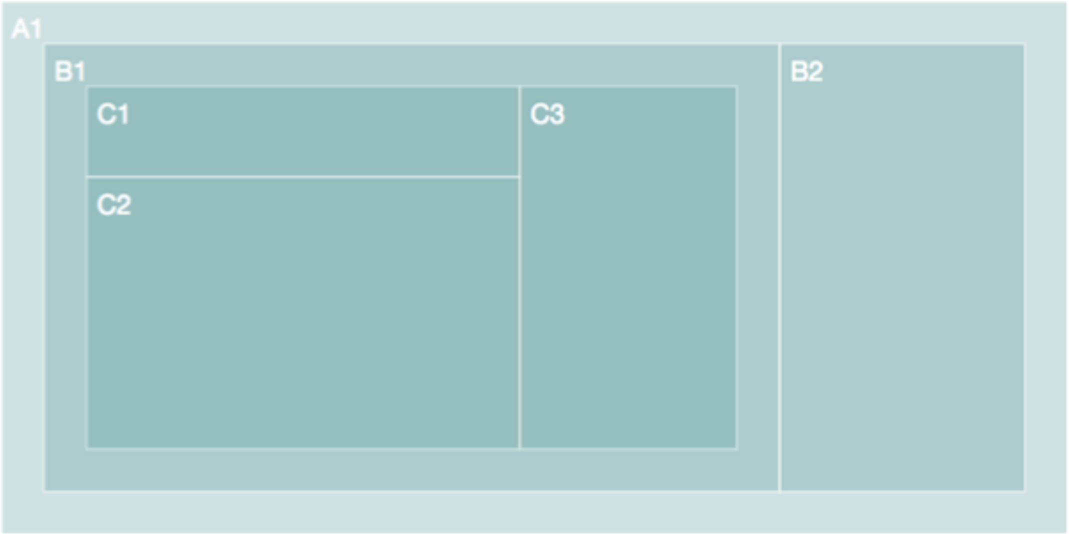
```
rootNode.sum(function(d) {
  return d.value;
});
```



Treemap Layout – Create a treemap

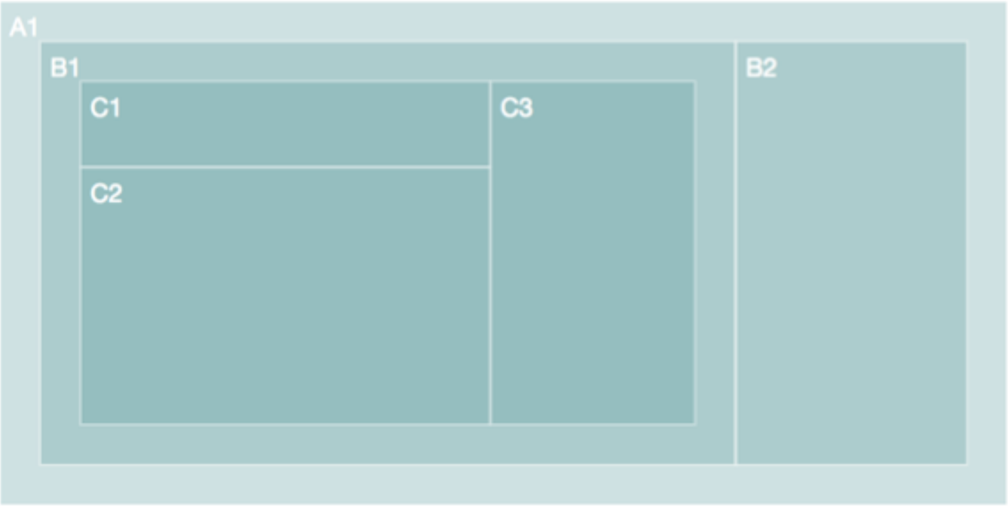
- Treemap generator: d3.treemap()
  - Take the screen size and padding/gaps between rectangles
  - Then, compute the *coordinates* of top-left corner *(x0, y0)* and bottom-right corner *(x1, y1)* of rectangles
    - The computed coordinates will be attached to corresponding nodes

```
var treemapLayout = d3.treemap()
  .size([width, height])
  .paddingOuter(16);

treemapLayout(rootNode);
```



Treemap Layout – Create a treemap

- Draw rectangles by
  - top-left corner *(x0, y0)*
  - bottom-right corner *(x1, y1)*




```
var allNodes = rootNode.descendants();
var nodes = d3.select('svg g')
  .selectAll('g')
  .data(allNodes)
  .enter()
  .append('g')
  .attr('transform', function(d) {
    return 'translate(' + [d.x0, d.y0] + ')';
  });

nodes
  .append('rect')
  .attr('width', function(d) {
    return d.x1 - d.x0;
  })
  .attr('height', function(d) {
    return d.y1 - d.y0;
  });
```

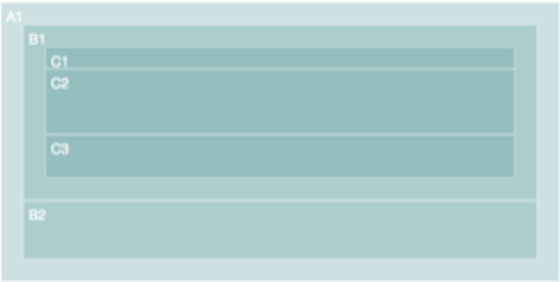
Treemap Layout – Tiling methods

- The d3 generates rectangles with a golden aspect ratio by default
- Also, we can set other tiling methods by .tile()

```
var treemapLayout = d3.treemap()
  .size([width, height])
  .tile(d3.treemapSlice)
  // d3.treemapDice
  // d3.treemapSlice
  // d3.treemapSliceDice
  .paddingOuter(16);

treemapLayout(rootNode);
```

Golden ratio

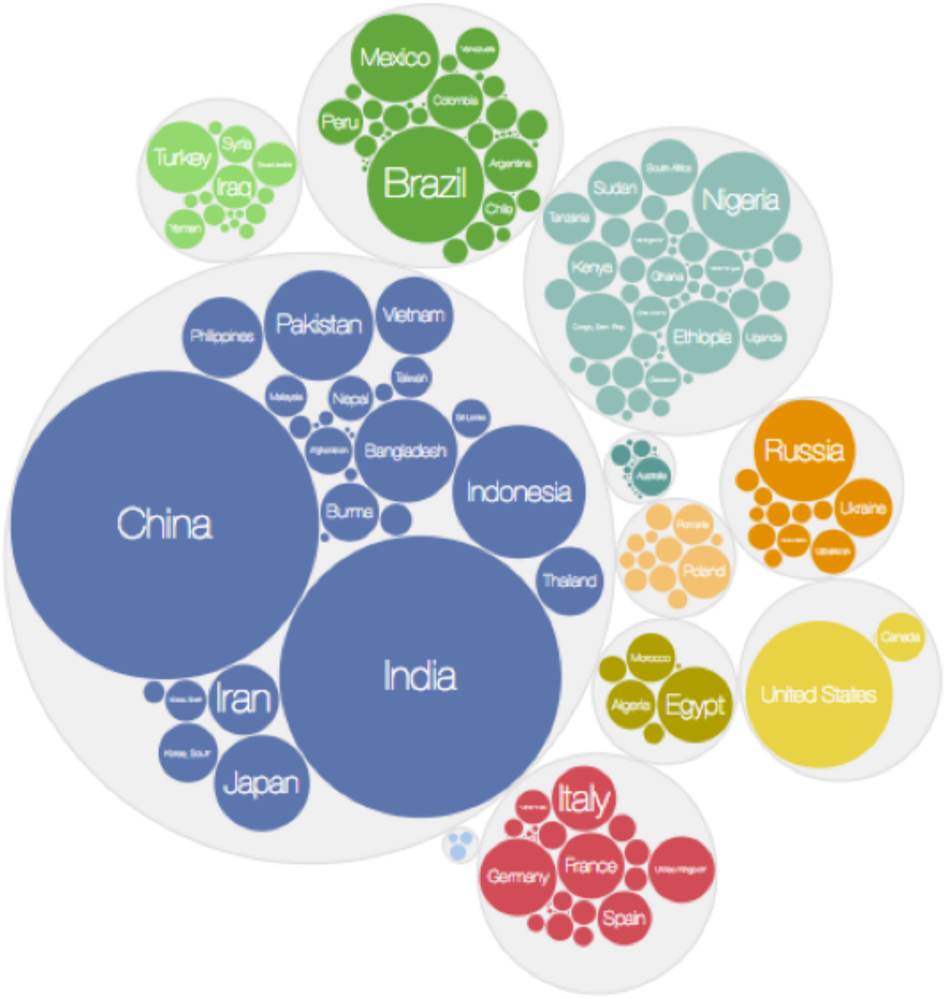
d3.treemapDice



d3.treemapSlice

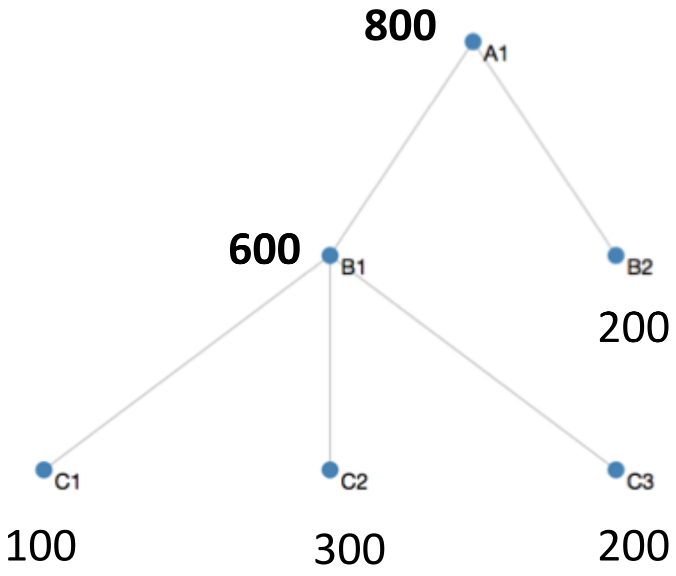
Pack Layout

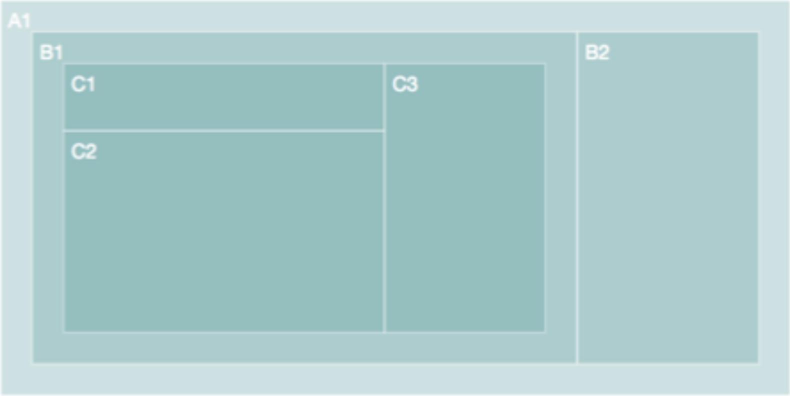
- The pack layout is similar to the treemap layout
  - **But circles instead of rectangles** are used to represent nodes.
  - Drawbacks
    - Does not use space as efficiently as a treemap
    - Has more distortion to represent parents' quantities due to wasted space
  - Advantage
    - The hierarchical structure is clearer

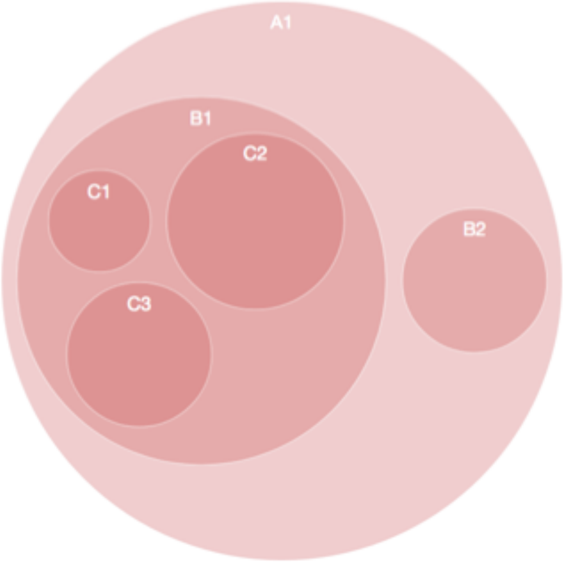


Pack Layout – Create a circle packing

- We use the same fake data



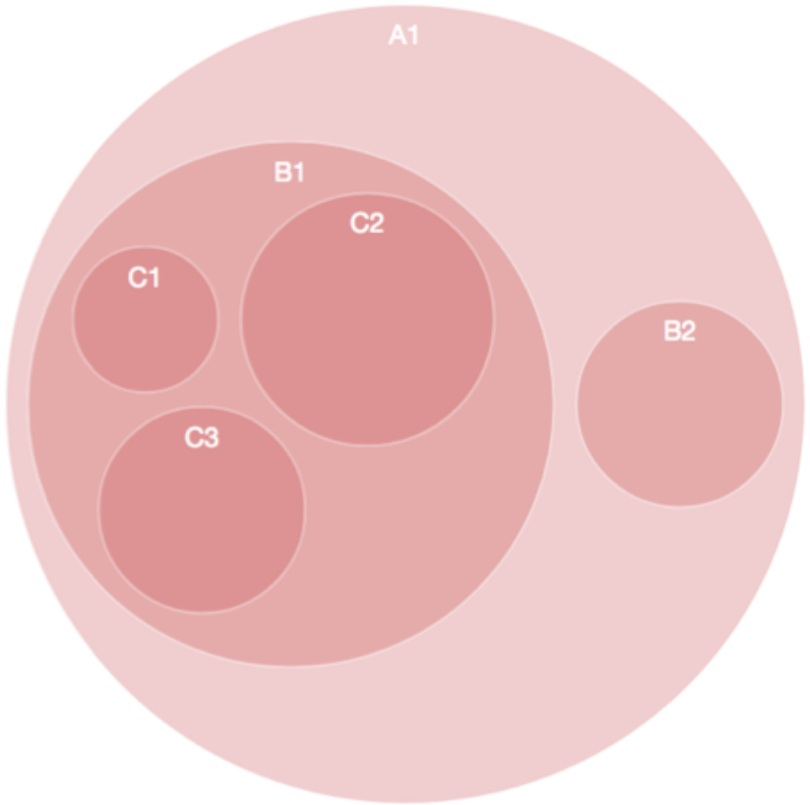




Pack Layout – Create a circle packing

- The pack generator also
  - Takes size of screen and padding between circles
  - Then, computes coordinates *(x, y)* and radius *r* of circles
    - The computed attributes will be attached to corresponding nodes

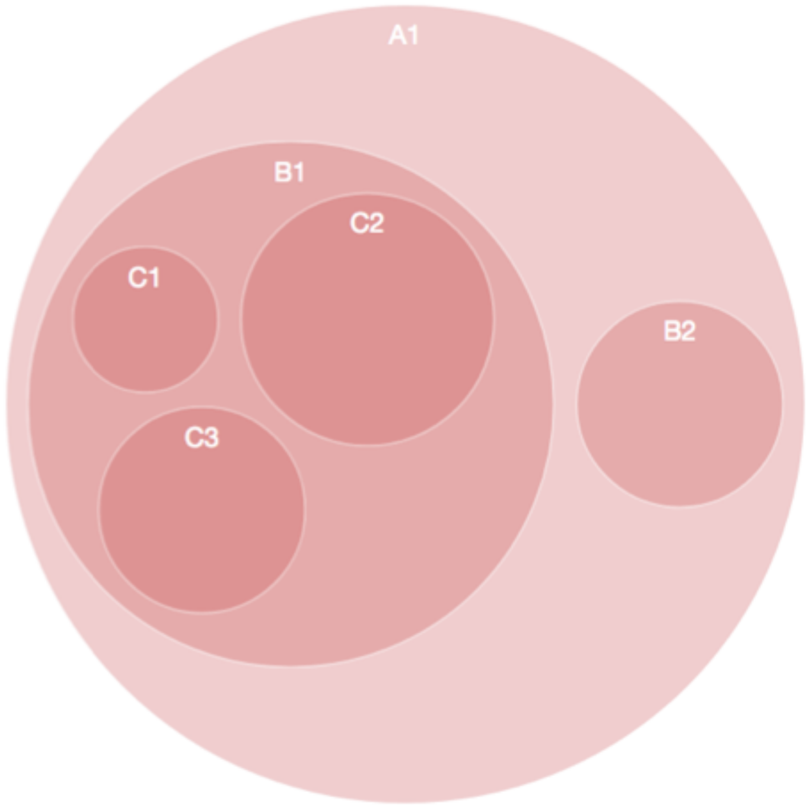
```
var packLayout = d3.pack()
  .size([width, height])
  .padding(10);

packLayout(rootNode);
```



Pack Layout – Create a circle packing

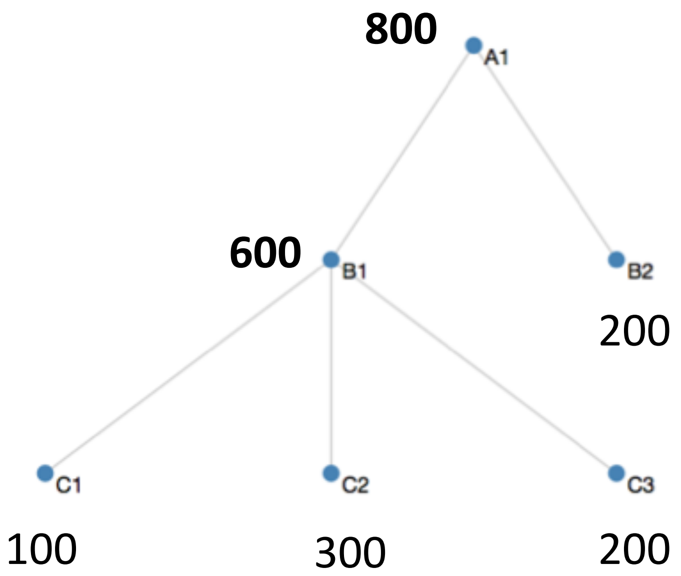
- Draw circles by coordinates *(x, y)* and radius *r* of circles

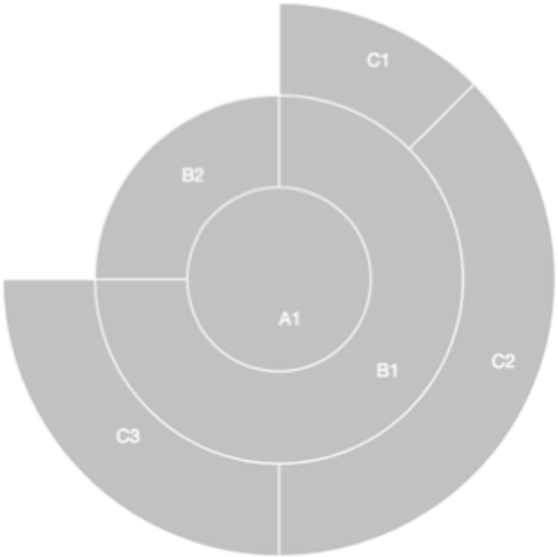
```
var allNodes = rootNode.descendants();
var nodes = d3.select('svg g')
  .selectAll('g')
  .data(allNodes)
  .enter()
  .append('g')
  .attr('transform', function(d) {
    return 'translate(' + [d.x, d.y] + ')';
  });

nodes
  .append('circle')
  .attr('r', function(d) {
    return d.r;
  });
```



Partition Layout

- The partition layout produces a space-filling variant of a node-link tree diagram.
  - nodes are drawn as solid areas (either rectangles or arcs)
  - their placement relative to other nodes reveals their position in the hierarchy





Partition Layout – Rectangular partition

- The rectangular partition generator also
  - Takes size of screen and padding between rectangles
  - Similar to treemap, computes the *coordinates* of top-left corner *(x0, y0)* and bottom-right corner *(x1, y1)* of rectangles
    - The computed attributes will be attached to corresponding nodes

```
var partitionLayout = d3.partition()
  .size([width, height])
  .padding(2);

partitionLayout(rootNode);
```

Partition Layout – Rectangular partition

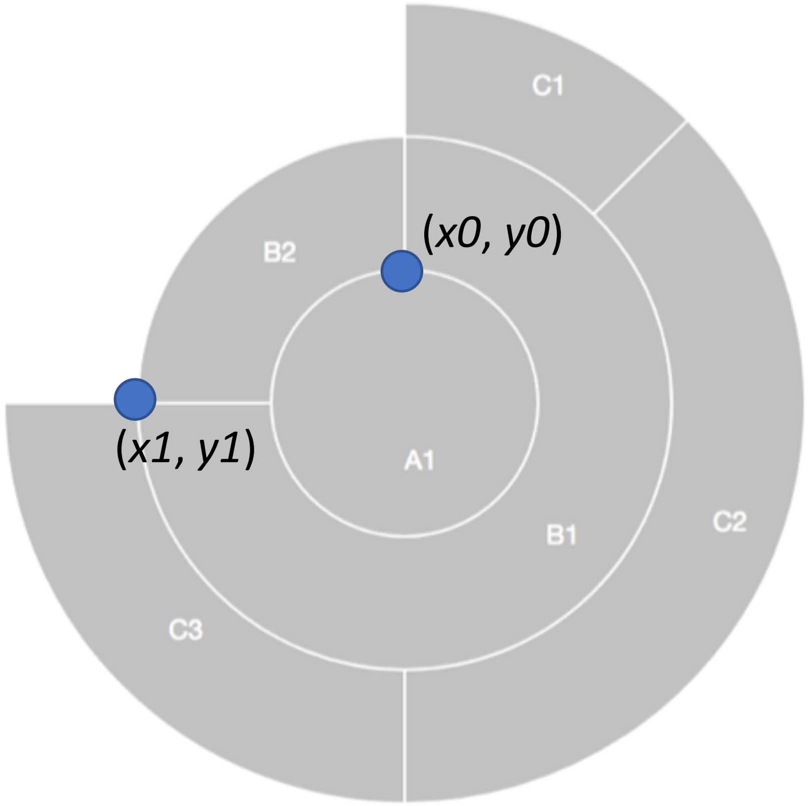
- Similar to treemap, draw rectangles by
    - top-left corner *(x0, y0)*
    - bottom-right corner *(x1, y1)*


```
var allNodes = rootNode.descendants();
var nodes = d3.select('svg g')
  .selectAll('g')
  .data(allNodes)
  .enter()
  .append('g')
  .attr('transform', function(d) {
    return 'translate(' + [d.x0, d.y0] + ')';
  });

nodes.append('rect')
  .attr('width', function(d) {
    return d.x1 - d.x0;
  })
  .attr('height', function(d) {
    return d.y1 - d.y0;
  });
```

Partition Layout – Sunburst partition

- The sunburst partition generator
  - Takes size of screen in the form of polar coordinates [*angle (in radians)*, *radius*]
  - **NO** padding setting
  - Then, computes four attributes *x0, x1, y0, and y1*
    - [*x0*, *x1*] is the extent of **angles (in radians)** of an arc
    - [*y0*, *y1*] is the extent of **radiuses** of an arc
    - From the perspective of polar coordinates
      - For example, B1 on the right
      - (*x0*, *y0*) and (*x1*, *y1*) are the **polar coordinates** of two corners of B1

```
var partitionLayout = d3.partition()
  .size([2 * Math.PI, radius]);

partitionLayout(rootNode);
```



Partition Layout – Sunburst partition

- Draw arcs by
  - arcGenerator
  - [*x0*, *x1*] : the extent of **angles (in radians)** of an arc
  - [*y0*, *y1*]: the extent of **radiuses** of an arc


```
var arcGenerator = d3.arc()
  .startAngle(function(d) { return d.x0; })
  .endAngle(function(d) { return d.x1; })
  .innerRadius(function(d) { return d.y0; })
  .outerRadius(function(d) { return d.y1; });
```

```
var allNodes = rootNode.descendants();
var nodes = d3.select('svg g')
  .selectAll('g')
  .data(allNodes)
  .enter()
  .append('g');

nodes.append('path')
  .attr('d', arcGenerator);
```