Layout and Animation Language

Why Would I Walk Through Mud?

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NY Times

How Fancy Layout Are Created Today

Pick a canned layout from ProtoViz (DSL for vis.)

- Limited to the library.
- Non-programmers cannot define their own.

If programmer, must write own layout engine.

- May takes days => can't quickly try layout ideas.
- ~10x more code if using Python/JavaScript

Our Language Mud

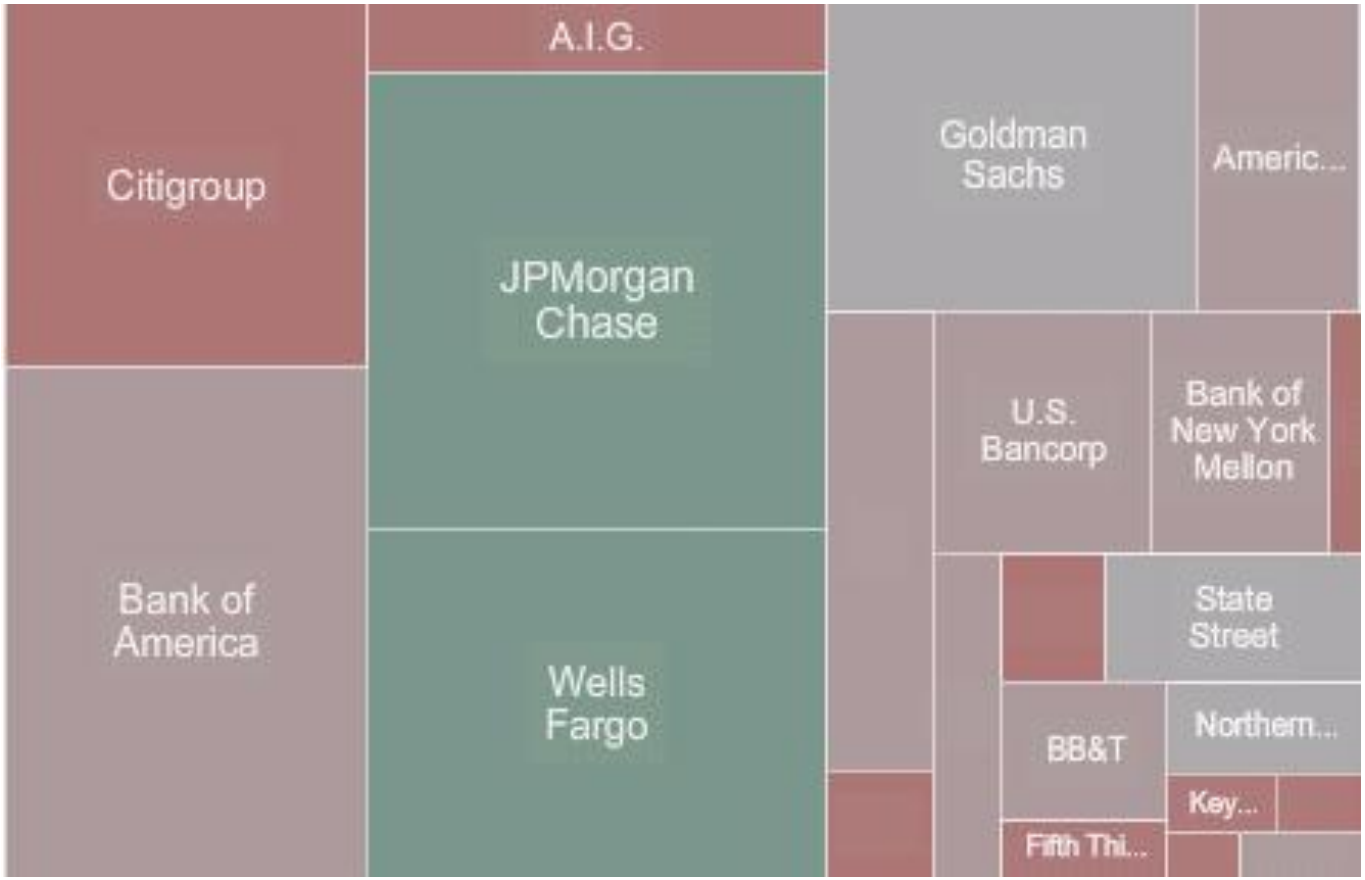
We choose **declarative programming** because

- Empower designers
  - Designers know the “what”, but not the “how”
- Naturally maps on human thought process for layout/visualization if well designed
- Eventually, programming by demonstration

Our compiler does **synthesis**. Why not use an off-the-shelf constraint solver? Ex: Cassowary[Badros], SMT solvers, Prolog.

- Performance
  - We compile down to tree passes. Linear Time.
  - No search and backtrack.

TreeMap of Financial Industry



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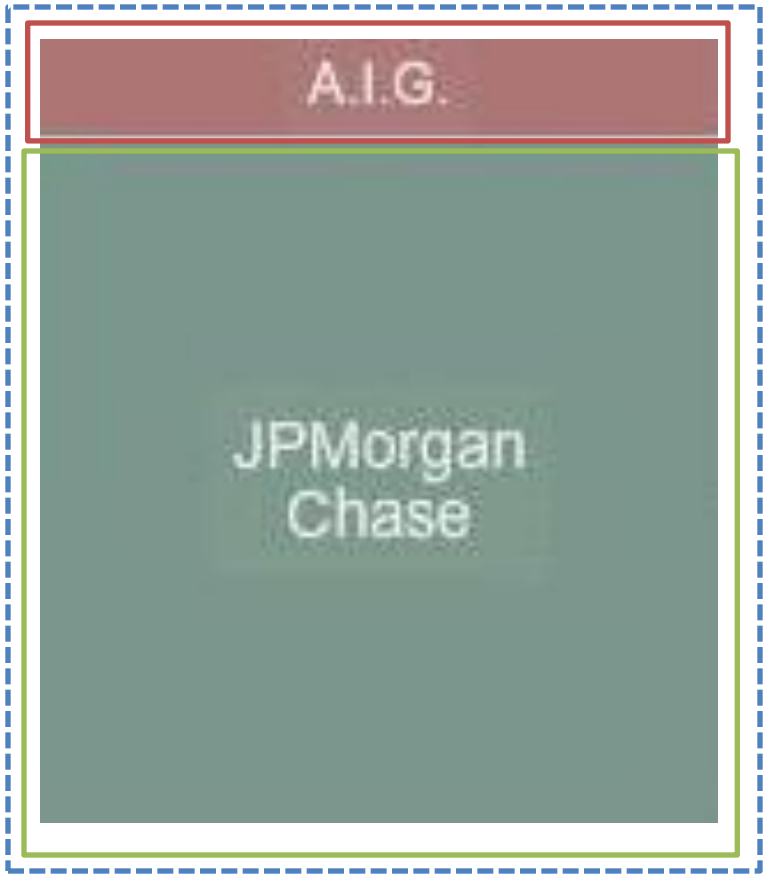
TreeMap on the Drawing Board



Designer's View

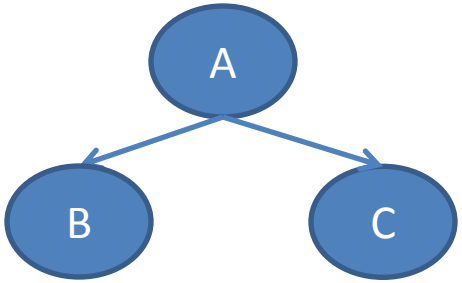
- Area is market capitalization
- Companies stacked vertically (or horizontally)
- Parent exactly encompasses children

Mud Hello World

1. Document is a tree.
2. We place local constraints

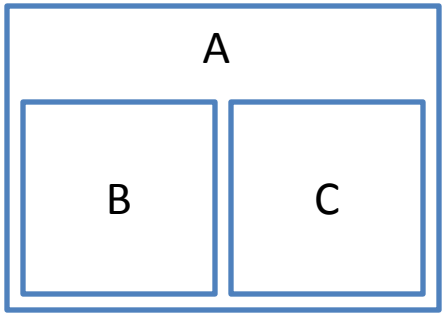
```
C.w = B.w = A.w / 2
```

```
<A>
    <B/>
    <C/>
</A>
```



In TreeMap, we have two building blocks

- H, the horizontal divider
- V, the vertical divider

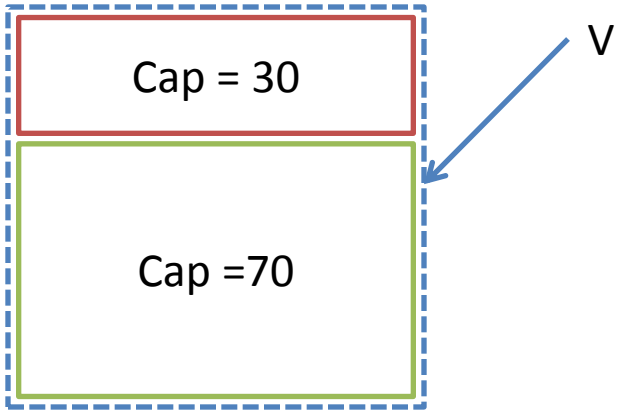


Specification of V

Let's write the spec in English and then translate it progressively into Mud

English Specification:

1. V is a rectangle with some style.
2. V area is divided vertically among its children
3. V's children are stacked on top of each other.
4. V area is proportional the sum its children's capitalization



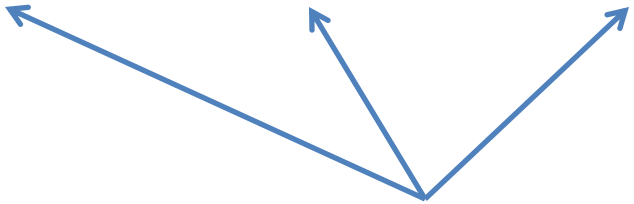
The Three Constraints

```
trait VDiv(h, w) {    // vertical division
  h = children[0].h + children[1].h
  w = children[0].w = children[1].w
}
trait VStack() {      // vertical stacking
  children.left = 0
  children[0].top = 0
  children[0].h = children[1].top
}
trait TreeMap(h, w, cap) { // area =~ cap
  SCALE * cap = h * w
  cap = children[0].cap + children[1].cap
}
```

V Is a Composition of Trait

Let's declare two new building blocks:

```
let V with RelCoord, BasicBoxStyle,
          VDiv, VStack, TreeMap
let H with RelCoord, BasicBoxStyle,
          HDiv, HStack, TreeMap
```



"Trait": Composable unit of behaviour

Are we done?

Tool: “your treemap is under-constrained”

- There are distinct ways to lay it out:

Fix: Root.h = 640

Alternative fix: set the aspect ratio.

Benefits of our semantics:

- Show possible solutions ==> Designer-friendly debugging
- Unique solution ==> predictable layout.

Prototyping with Mud

Mud flexibility allows designers to experiment.

Example: Let's make treemap fixed size!

- At Root node: `h = 640, w = 320`
- Tool tells us to make the scaling factor a variable

Mud compiler produces the new layout engine

- New engine requires four, rather than three passes
- The extra pass computes the right scaling factor.

Animations

How to add animation?

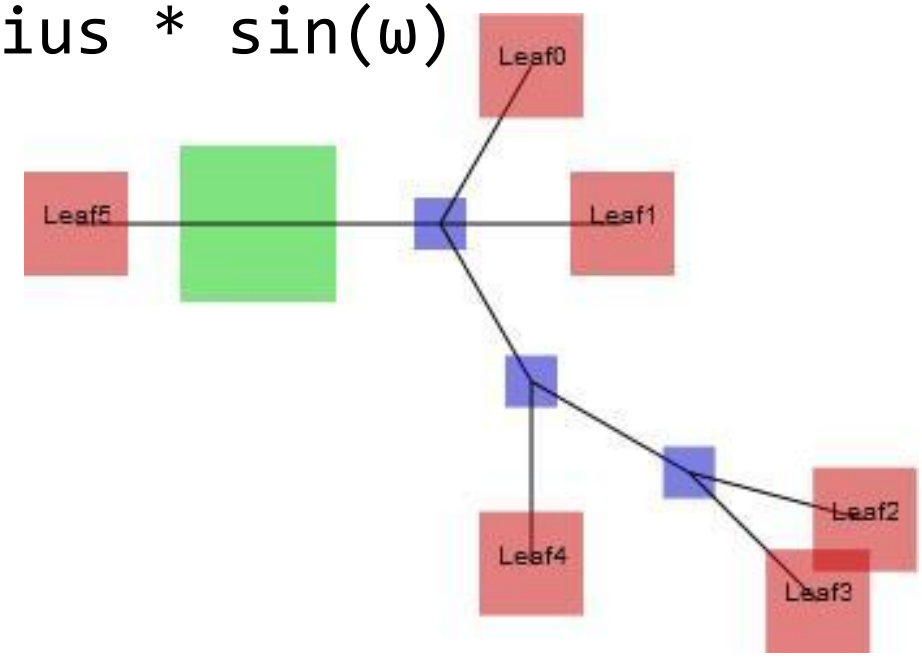
ie, transform the tilemap from Jan to Feb layout?

1. Interpolate Jan-to-Feb capitalization data, obtaining new capitalization for each frame
2. Update the document tree with this data
3. Rerun the layout engine (recompute layout)

Radial Layout

Polar coordinates in Mud

```
trait Polar (x, y, ω, radius) {
  x = parent.x + radius * cos(ω)
  y = parent.y + radius * sin(ω)
}
```



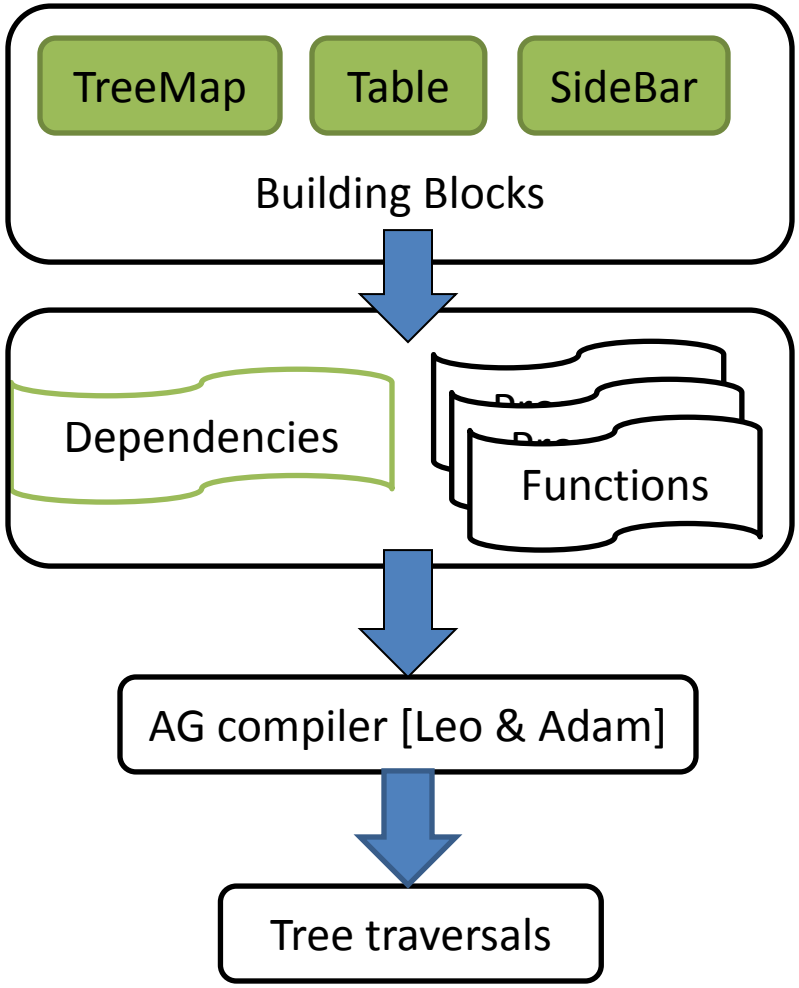
Under the Hood

Specifications
Bi-directional constraints
Declarative/relational

Directional constraints
Operational/functional

Attribute Grammar

Layout Engine



Ongoing Work

The rubber meets the mud:

- Data visualization: this summer @ Nokia Lab
- GUIs, documents will be next
- Learn how designers would use and debug Mud

Come see the demos at poster session

- Vertical integration of almost entire browser stack
- Give us your ideas for data vis of personal data

Summary

- Declarative programming for designers (data visualization, GUIs, documents).
- Fast layout for big data and small battery. No search, no fixed-point. Instead, linear time, parallel.
- Constraints compiler based on two-step synthesis. Local constraints to functions. Functions to global solver.

That is all folks