

# Delivering Variable Fonts to the web at scale

# Presenters



**Garret Rieger**  
Production & Standards

**Google Fonts**



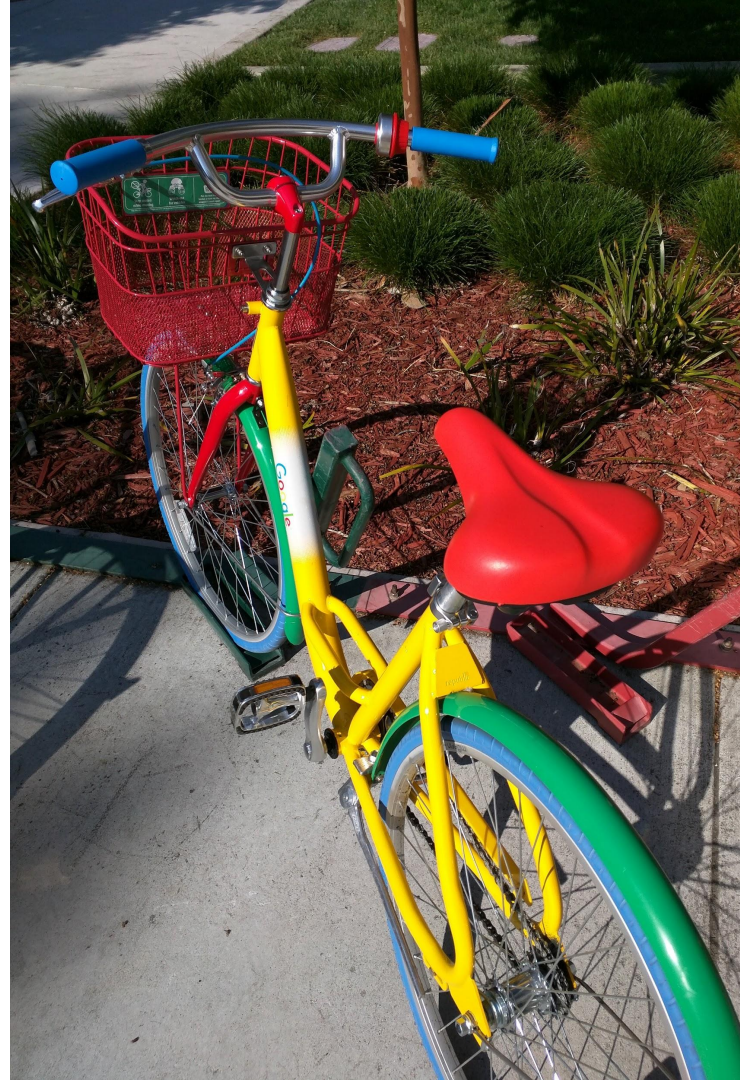
**Roderick Sheeter**  
Tech Lead/Manager

**Google Fonts**

# Google Fonts?

# What is "Google Fonts"?

- Free, open-source, font collection
- Free, public, content delivery
- We want to serve all Google users



# What does Google Fonts do?

- Maintain & publish collection
- Web API
- Android API
- Tools and supporting technologies



# Variable Fonts?

# What is a "Variable Font"?

"A variable font is a single font file that behaves like multiple fonts."

- John Hudson, "Introducing OpenType Variable Fonts" on Medium

# What is a "Static Font"?

Light

Normal

SemiBold

**Bold**

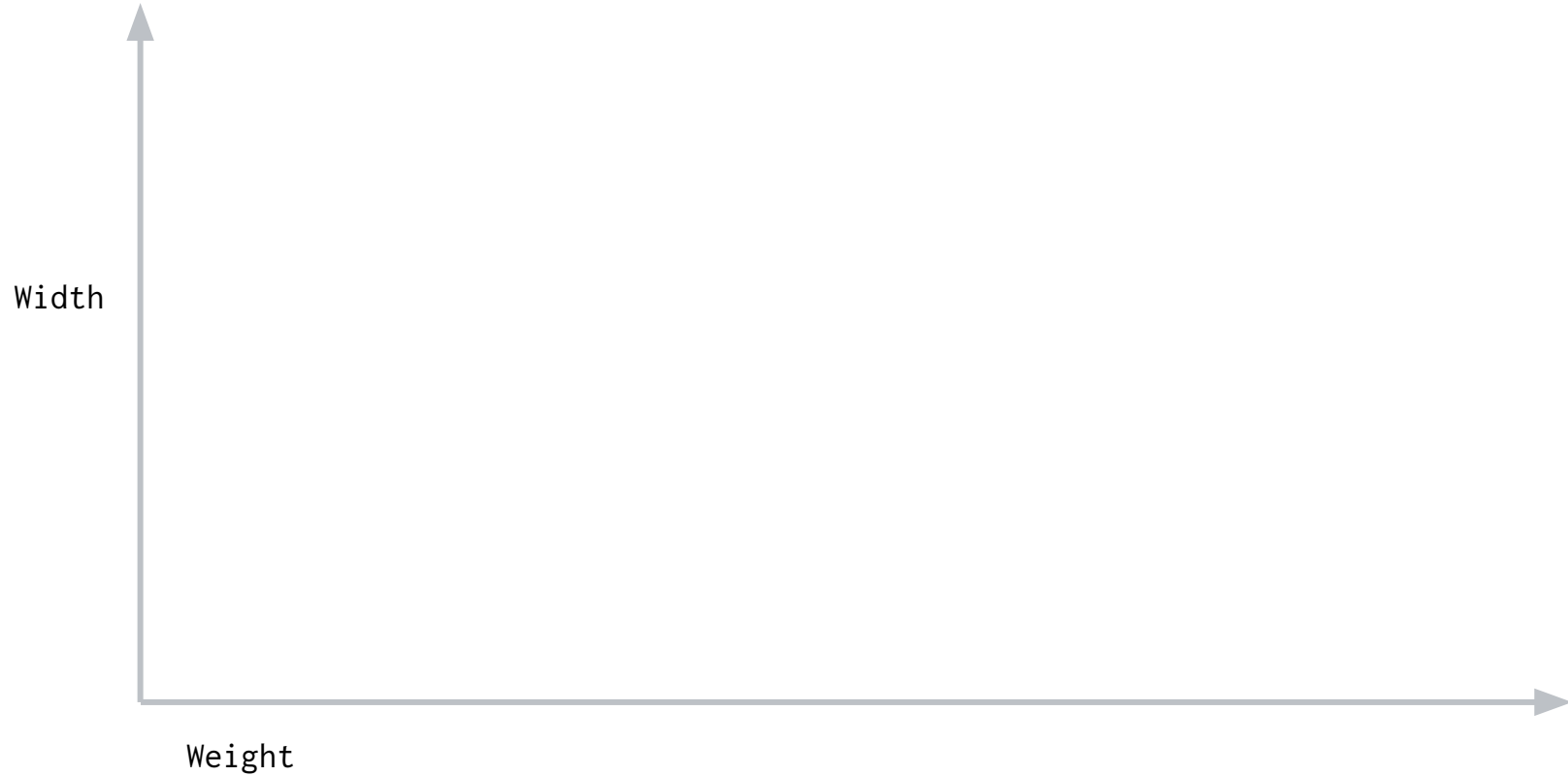
**ExtraBold**



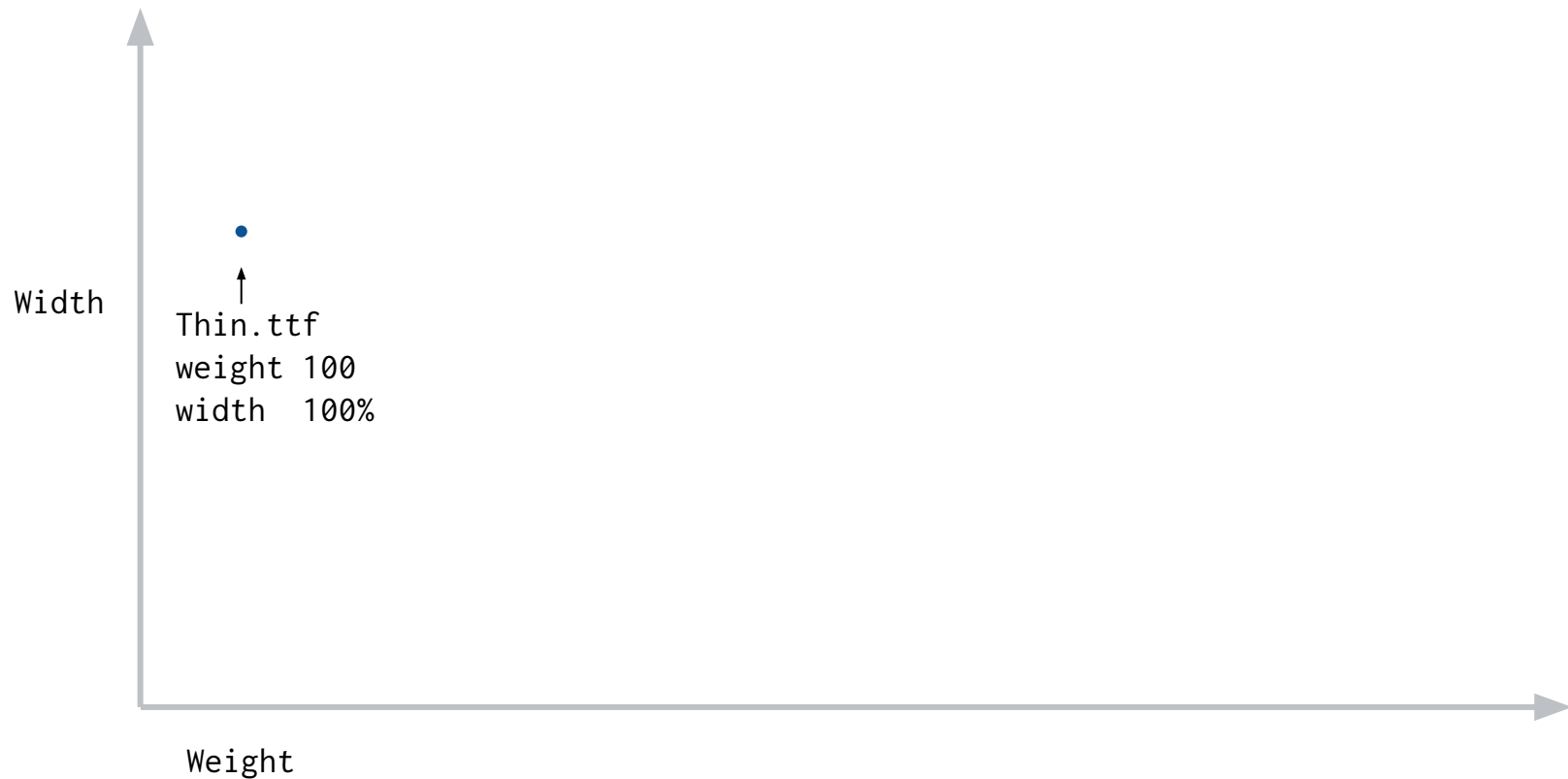
Weight axis



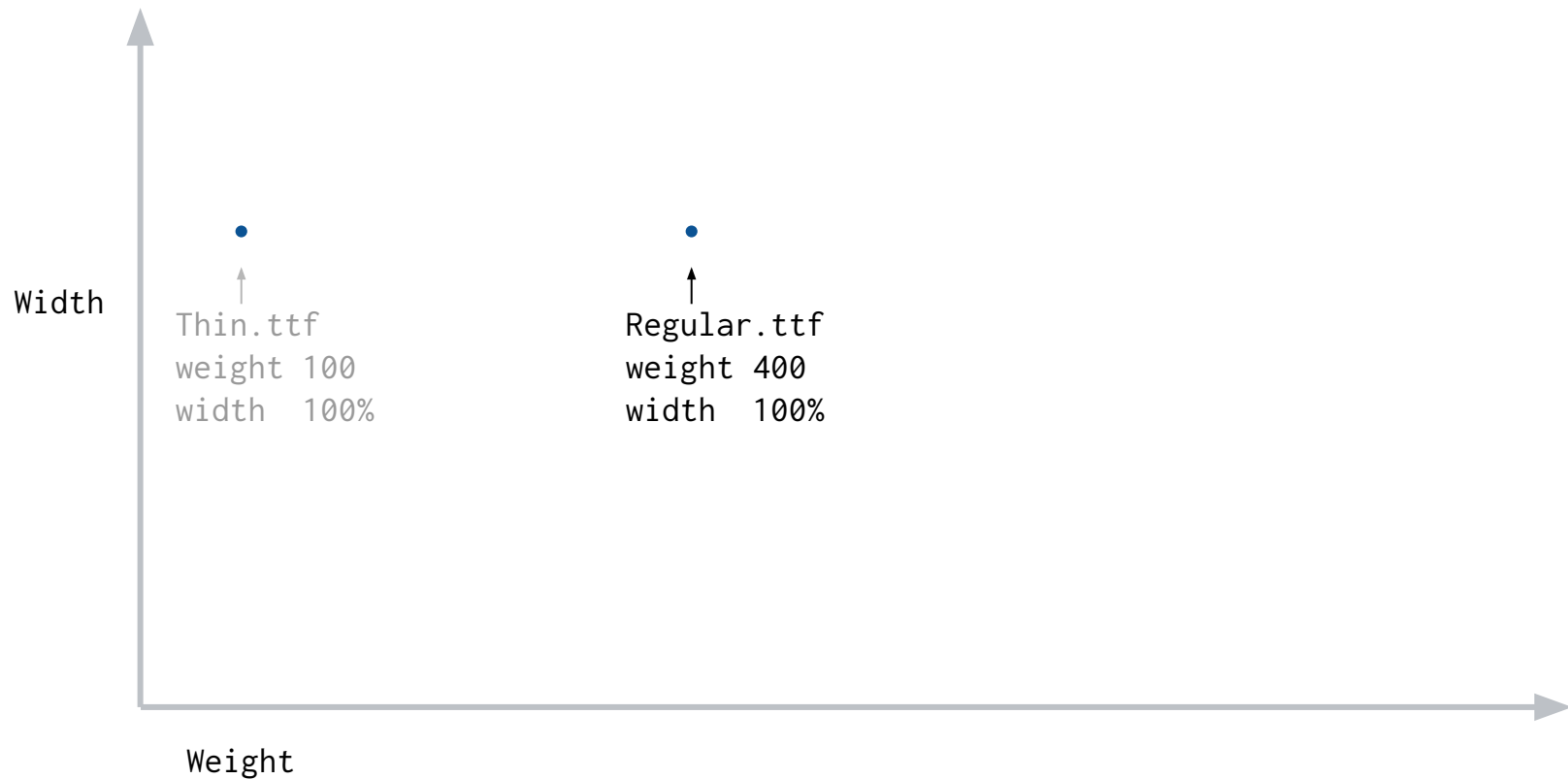
# What is a "Static Font"?



# What is a "Static Font"?



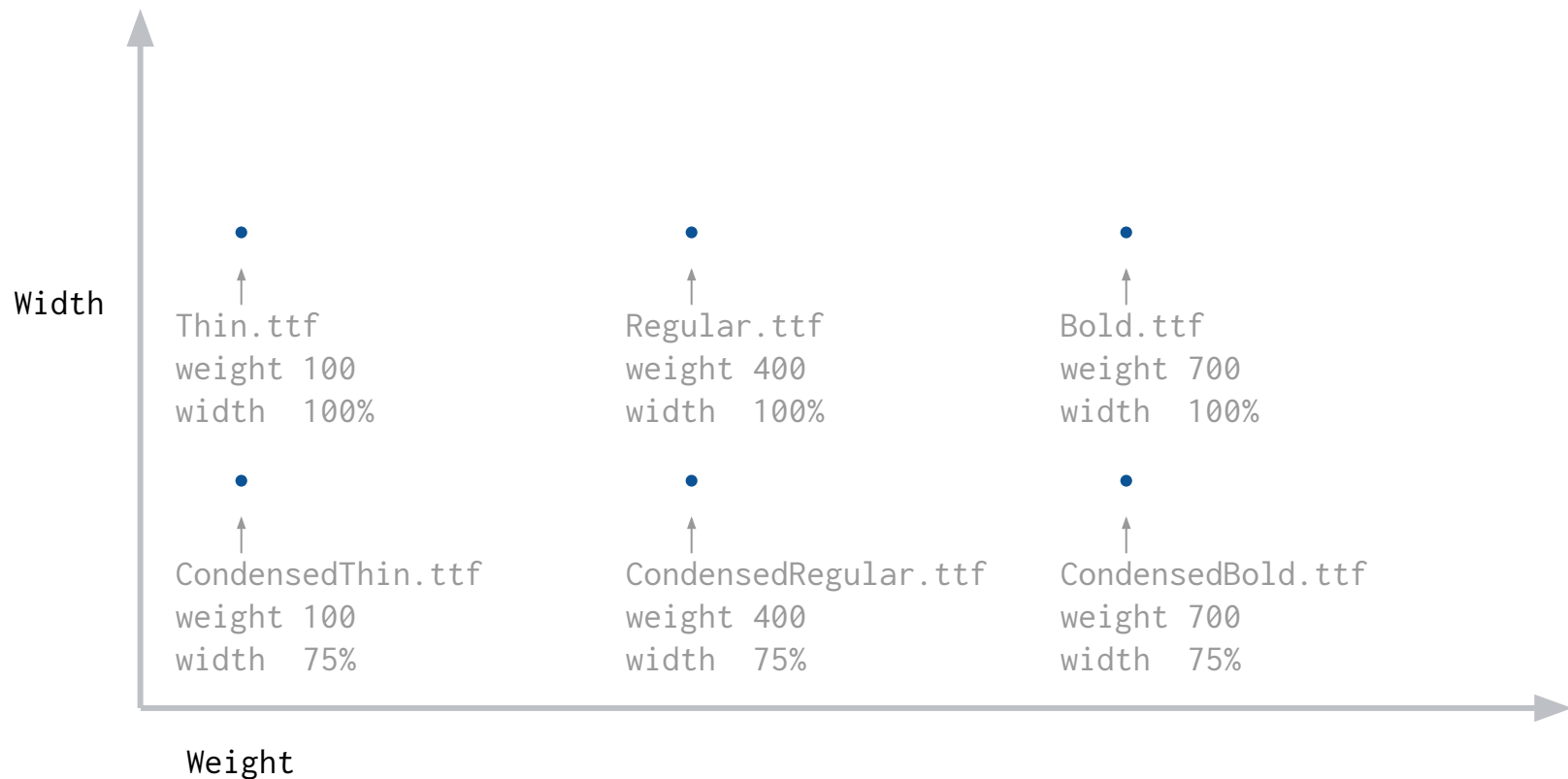
# What is a "Static Font"?



# What is a "Static Font"?



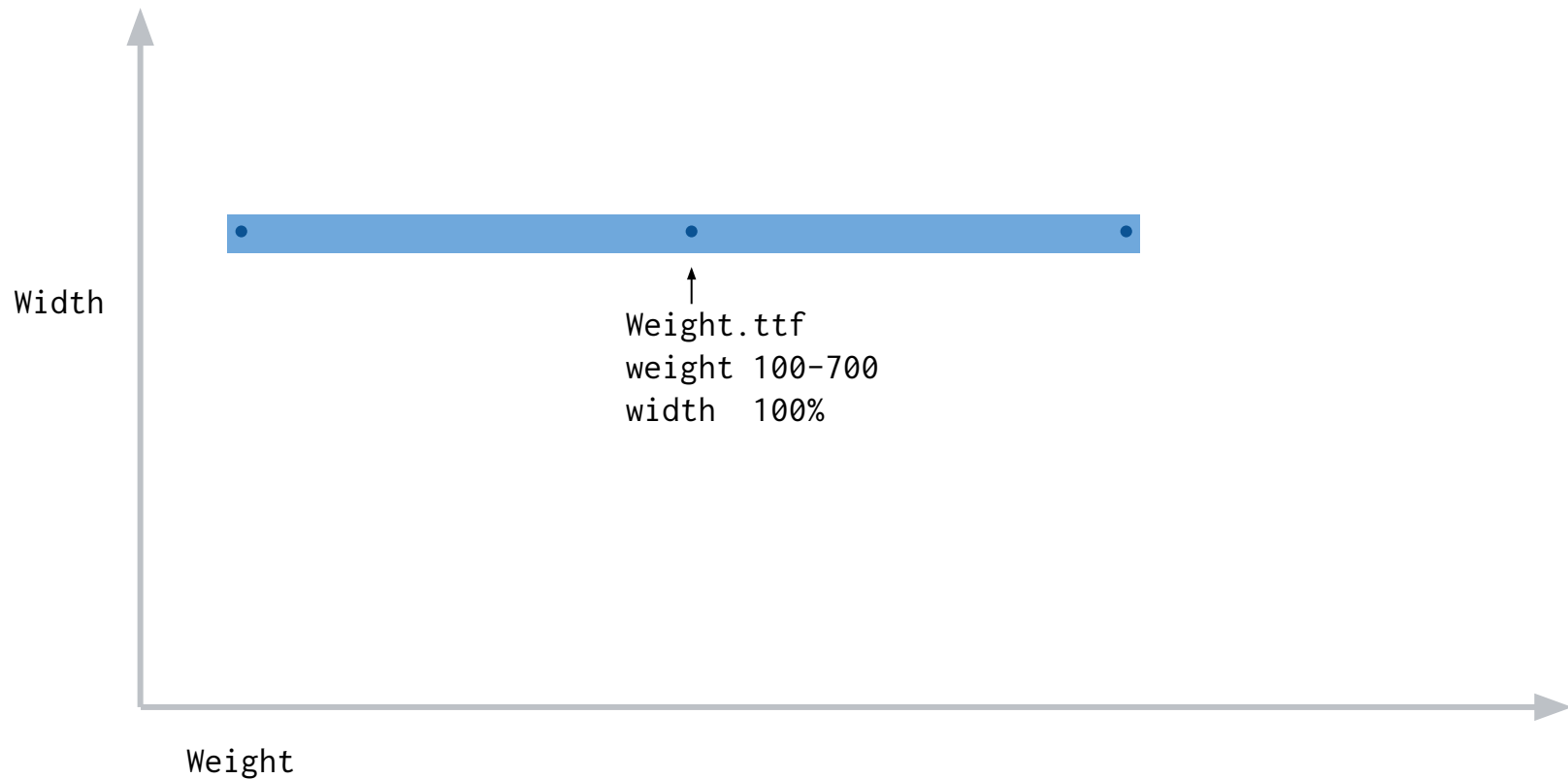
# What is a "Static Font"?



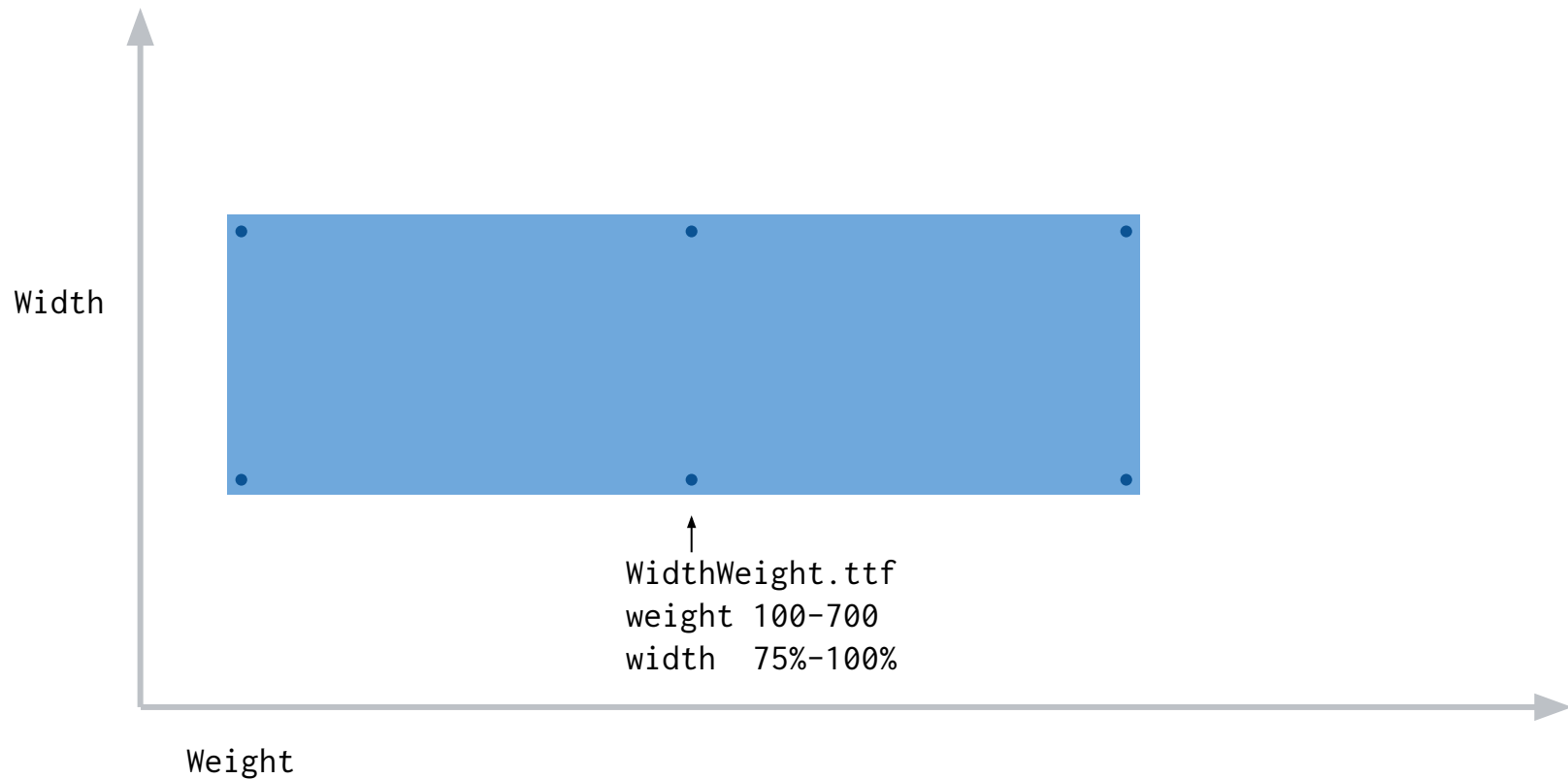
# What is a "Static Font"?



# What is a "Variable Font"?



# What is a "Variable Font"?





# What axes do variable fonts support?

<b>ital</b>	Italic, from Roman (0) to Italic (1)
<b>opsz</b>	Optical size, $>0$
<b>slnt</b>	Slant, $-90^\circ < \text{slnt} < 90^\circ$
<b>wdth</b>	Width, $>0$ (and typically $50\% \leq \text{wdth} \leq 200\%$ )
<b>wght</b>	Weight, $1 \leq \text{wght} \leq 1000$

*And custom axes! Up to  $2^{16}$  total axes in a font! For example:*

<b>MONO</b>	From Proportional font (0) to Monospace font (1)
-------------	--

# Benefits of Variable Fonts

Compress

Consolidate a font family into fewer, smaller files

Finesse

Give display systems increased control over type

Express

Give designers increased control over type

# Benefits of Variable Fonts

## Compress

Consolidate a font family into fewer, smaller files

Light

Normal

SemiBold

**Bold**

**ExtraBold**

# Benefits of Variable Fonts

## Compress

Consolidate a font family into fewer, smaller files

### Pixel, Android O: Roboto Fonts

Roboto-Black.ttf	RobotoCondensed-Bold.ttf
Roboto-BlackItalic.ttf	RobotoCondensed-BoldItalic.ttf
Roboto-Bold.ttf	RobotoCondensed-Italic.ttf
Roboto-BoldItalic.ttf	RobotoCondensed-Light.ttf
Roboto-Italic.ttf	RobotoCondensed-LightItalic.ttf
Roboto-Light.ttf	RobotoCondensed-Medium.ttf
Roboto-LightItalic.ttf	RobotoCondensed-MediumItalic.ttf
Roboto-Medium.ttf	RobotoCondensed-Regular.ttf
Roboto-MediumItalic.ttf	
Roboto-Regular.ttf	
Roboto-Thin.ttf	
Roboto-ThinItalic.ttf	

~6MB



### Future Variable Font

Roboto-min-VF.ttf

~3MB

# Benefits of Variable Fonts

Finesse

Give display systems increased control over type

# Benefits of Variable Fonts

## Finesse

Give display systems increased control over type

I remembered the case well, for it was one in which Holmes had taken an interest on account of the peculiar ferocity of the crime and the wanton brutality which had marked all the actions of the assassin. The commutation of his death sentence had been due to some doubts as to his complete sanity, so atrocious was his conduct. Our wagonette had topped a rise and in front of us rose the huge expanse of the moor, mottled with gnarled and craggy cairns and tors. A cold wind swept down from it and set us shivering. Somewhere there, on that desolate plain, was lurking this fiendish man, hiding in a burrow like a wild beast, his heart full of malignancy against the whole race which had cast him out. It needed but this to complete the grim suggestiveness of the barren waste, the chilling wind, and the darkling sky. Even Baskerville fell silent and pulled his overcoat more closely around him.

← CSS

```
text-align: justify
```

# Benefits of Variable Fonts

## Finesse

Give display systems increased control over type

I remembered the case well, for it was one in which Holmes had taken an interest on account of the peculiar ferocity of the crime and the wanton brutality which had marked all the actions of the assassin. The commutation of his death sentence had been due to some doubts as to his complete sanity, so atrocious was his conduct. Our wagonette had topped a rise and in front of us rose the huge expanse of the moor, mottled with gnarled and craggy cairns and tors. A cold wind swept down from it and set us shivering. Somewhere there, on that desolate plain, was lurking this fiendish man, hiding in a burrow like a wild beast, his heart full of malignancy against the whole race which had cast him out. It needed but this to complete the grim suggestiveness of the barren waste, the chilling wind, and the darkling sky. Even Baskerville fell silent and pulled his overcoat more closely around him.

← CSS

```
text-align: justify
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**Variable Font** →

I remembered the case well, for it was one in which Holmes had taken an interest on account of the peculiar ferocity of the crime and the wanton brutality which had marked all the actions of the assassin. The commutation of his death sentence had been due to some doubts as to his complete sanity, so atrocious was his conduct. Our wagonette had topped a rise and in front of us rose the huge expanse of the moor, mottled with gnarled and craggy cairns and tors. A cold wind swept down from it and set us shivering. Somewhere there, on that desolate plain, was lurking this fiendish man, hiding in a burrow like a wild beast, his heart full of malignancy against the whole race which had cast him out. It needed but this to complete the grim suggestiveness of the barren waste, the chilling wind, and the darkling sky. Even Baskerville fell silent and pulled his overcoat more closely around him.

# Benefits of Variable Fonts

Express

Give designers increased control over type



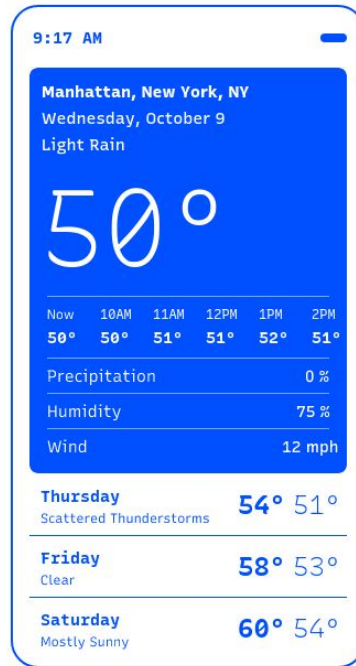
# Benefits of Variable Fonts

## Express

Give designers increased control over type

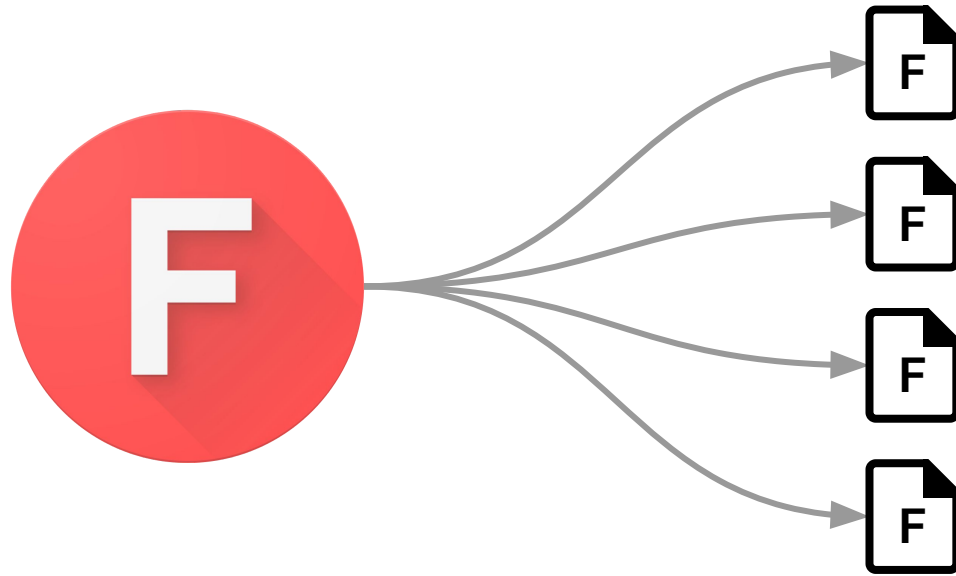


```
INFO:fontTools.varLib:Merging TT hinting
INFO:fontTools.varLib:Generating GSUB FeatureVariations
INFO:fontTools.varLib:Setting OS/2.usWidthClass = 800
Processing font-betas/work-in-progress/Recursive-mono-full
font-betas/work-in-progress/Recursive-mono-full--ital_only
Compressed 179390 to 104331.
(venv)
~/type/recursive → master
> banner $(pwd)
```

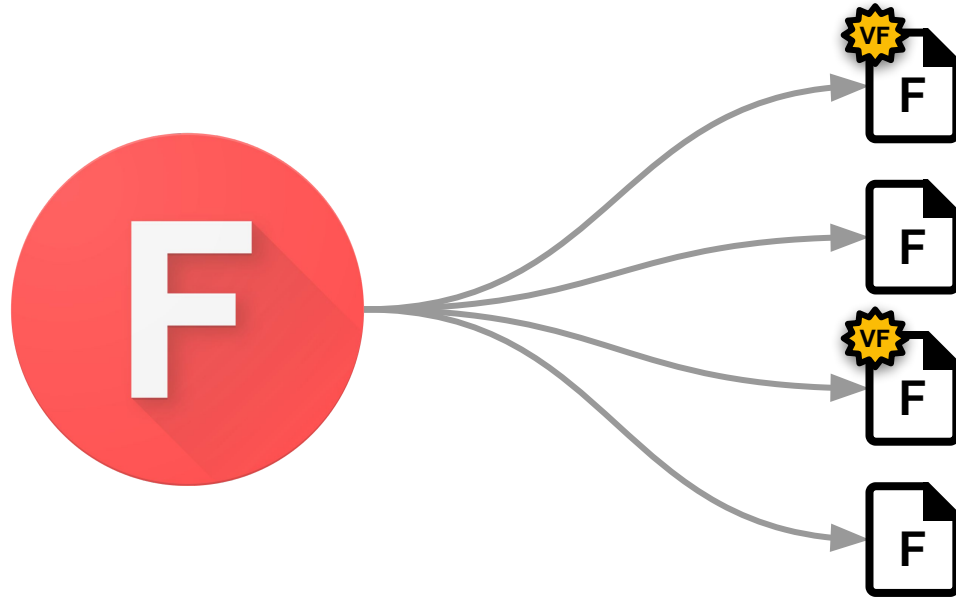


# Delivering Variable

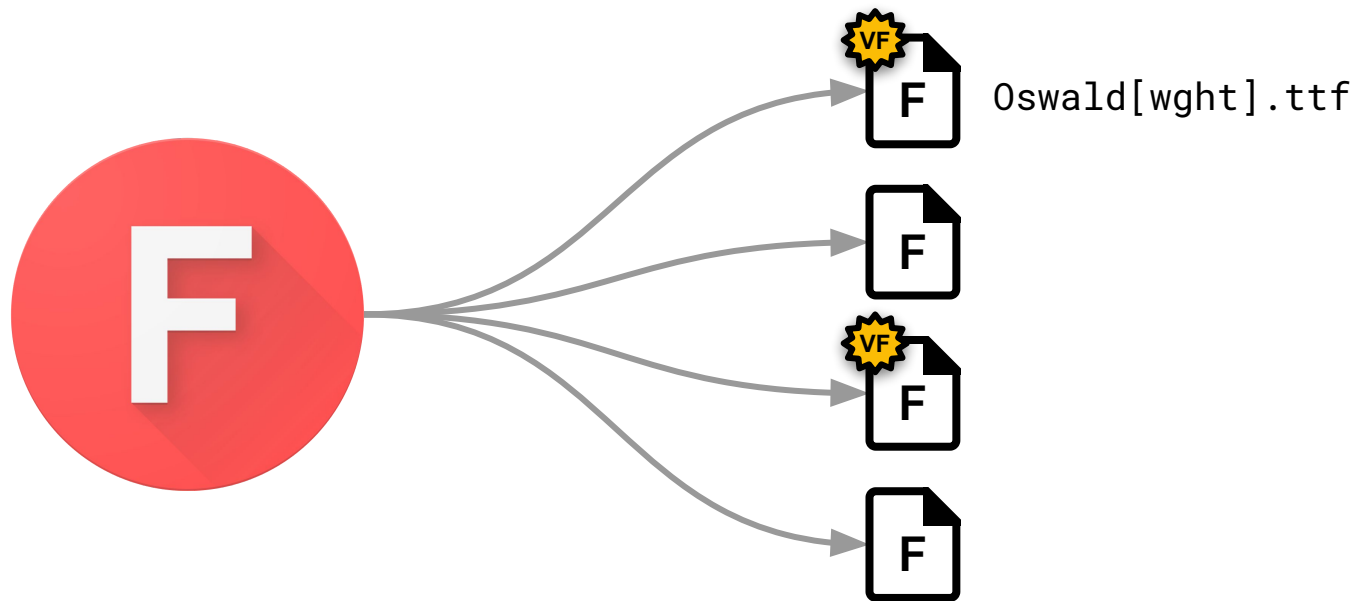
# Old Font, New Tricks



# Old Font, New Tricks

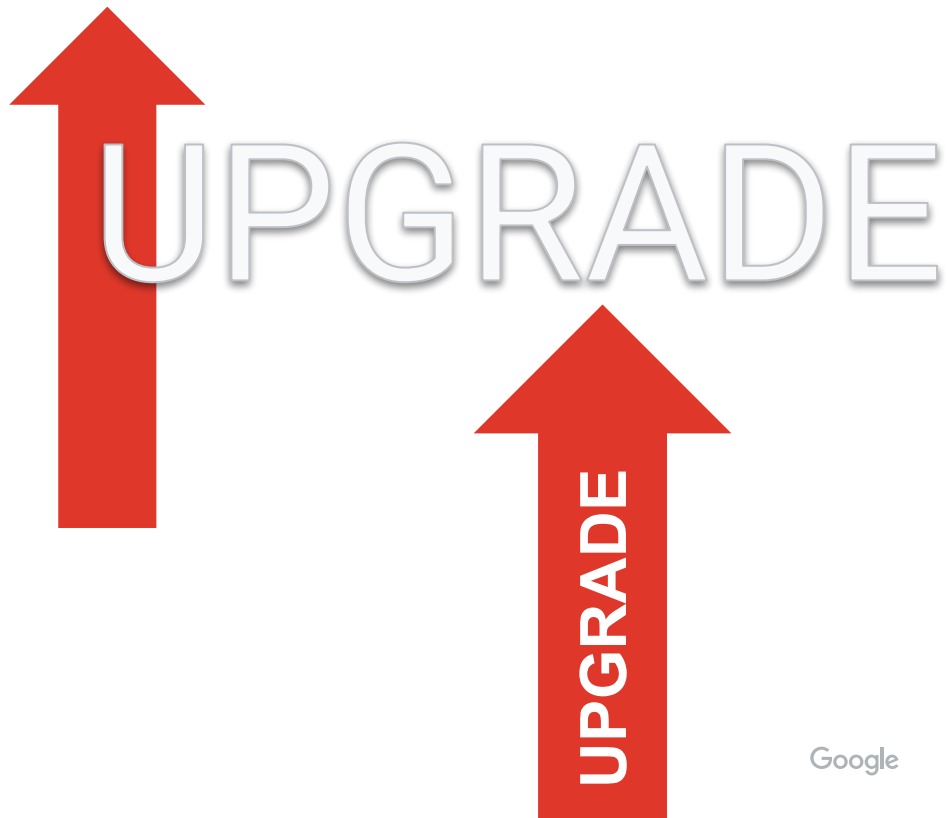


# Old Font, New Tricks



# Upgrading Existing Families

- Point compatibility
- Metrics changes
- Hinting



“ Why’d you have to go  
and make things so  
complicated? ”

---

**Avril Lavigne**  
*Singer, Songwriter*

Variable Fonts Are Complicated

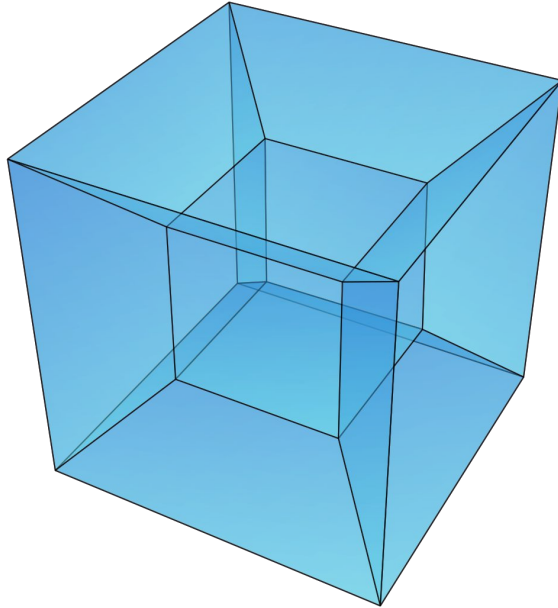
*VARIABLE*  
*FONTS*



# Variable Fonts Are Complicated

a a a a a a  
a a a a a a  
a a a a a a  
a a a a a a  
a a a a a a  
a a a a a a  
a a a a a a  
a a a a a a  
a a a a a a  
a a a a a a

# Variable Fonts Are Complicated



# Browser Support

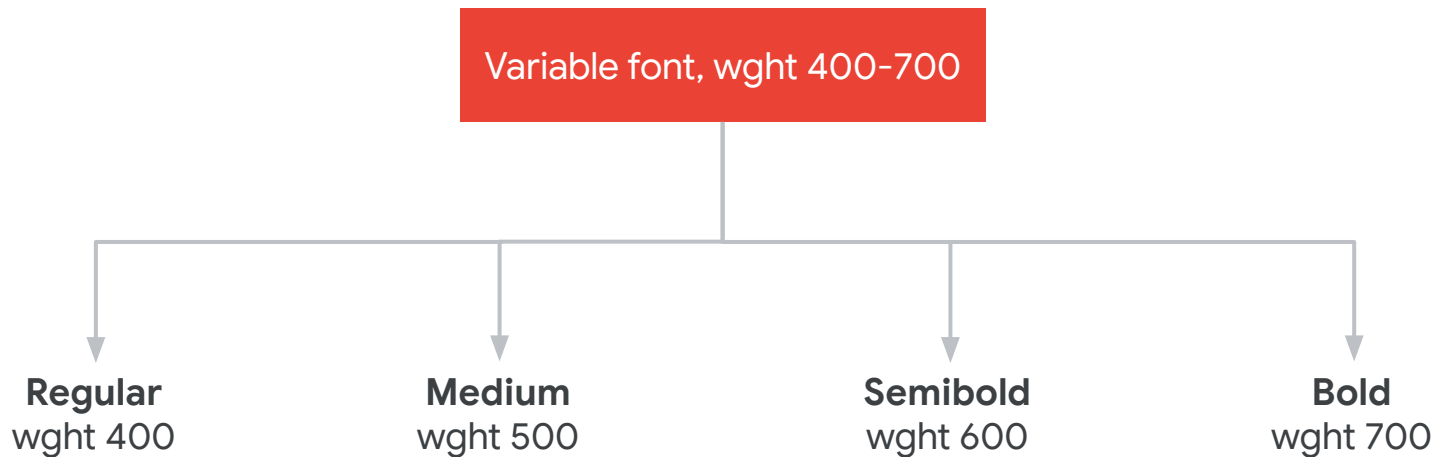
Global VF support



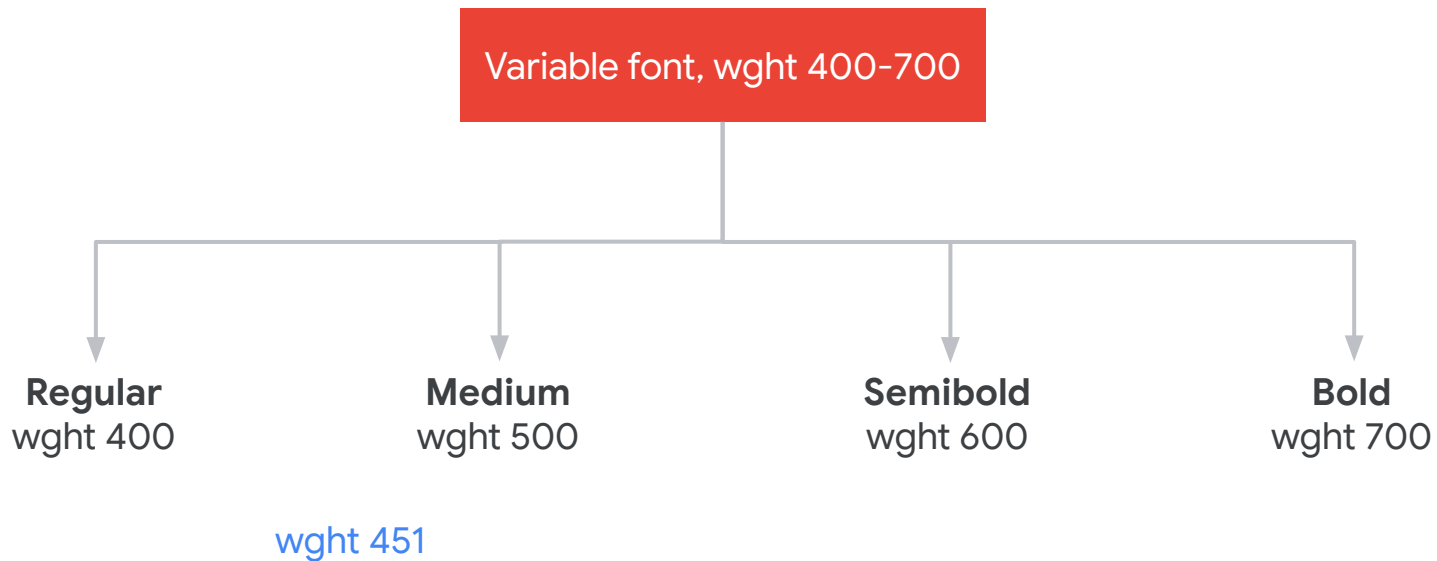
# Serving Legacy Browsers

Variable font, wght 400-700

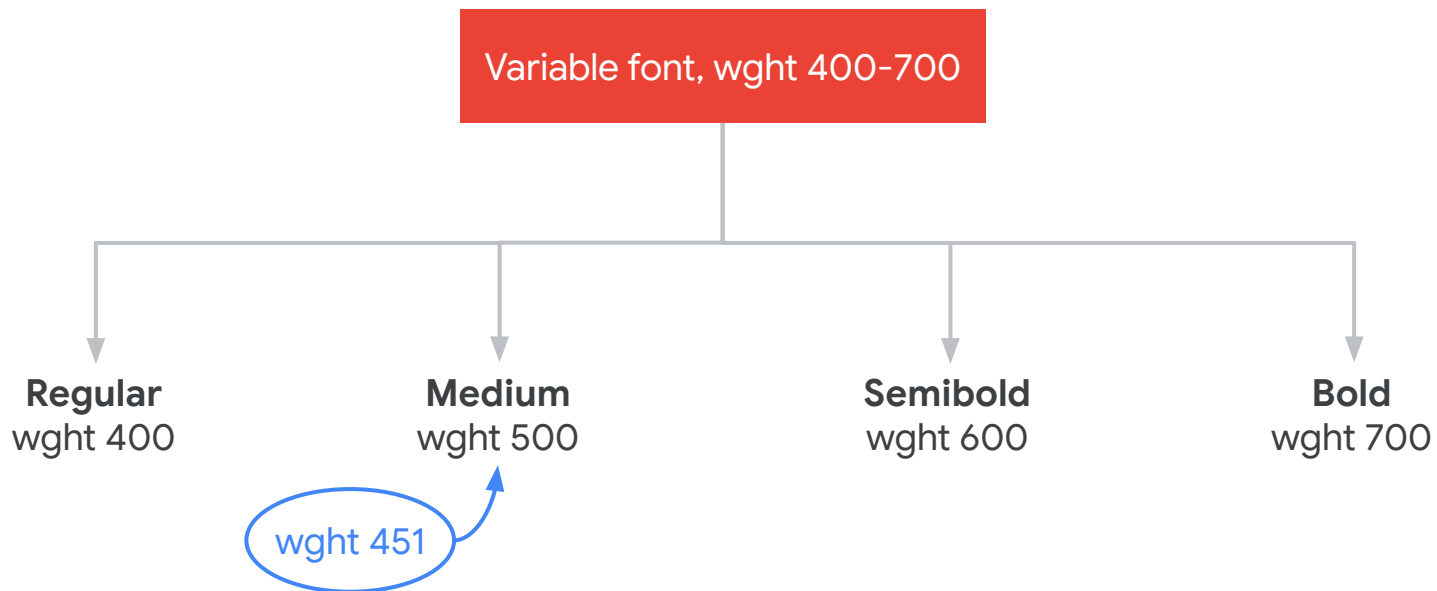
# Serving Legacy Browsers



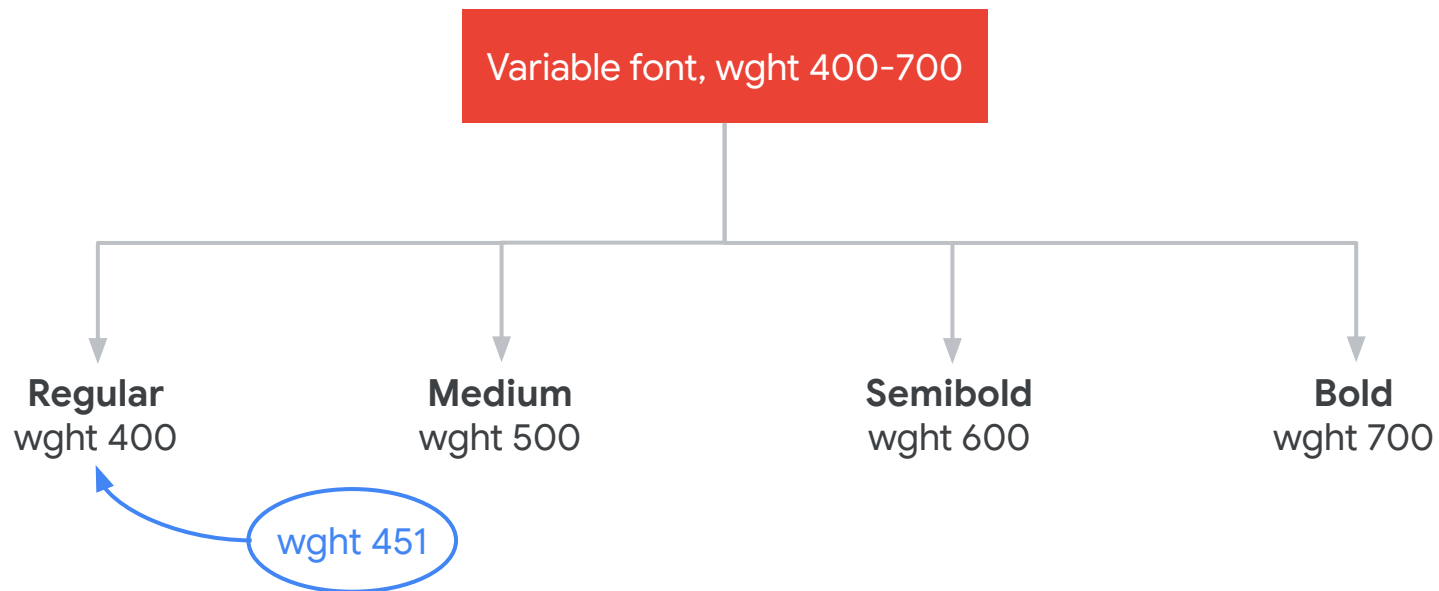
# Serving Legacy Browsers



# Serving Legacy Browsers



# Serving Legacy Browsers

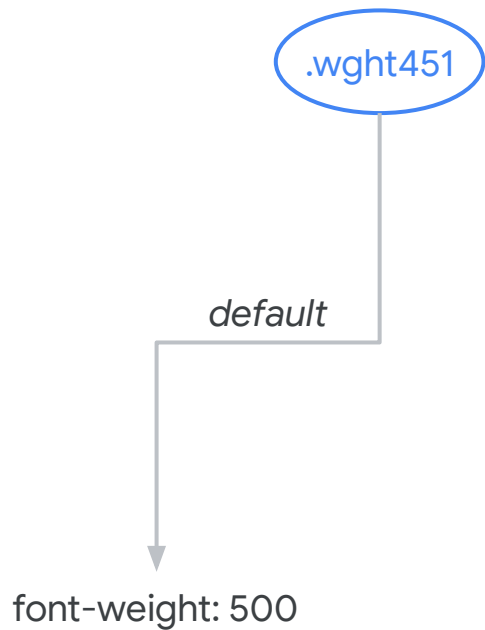




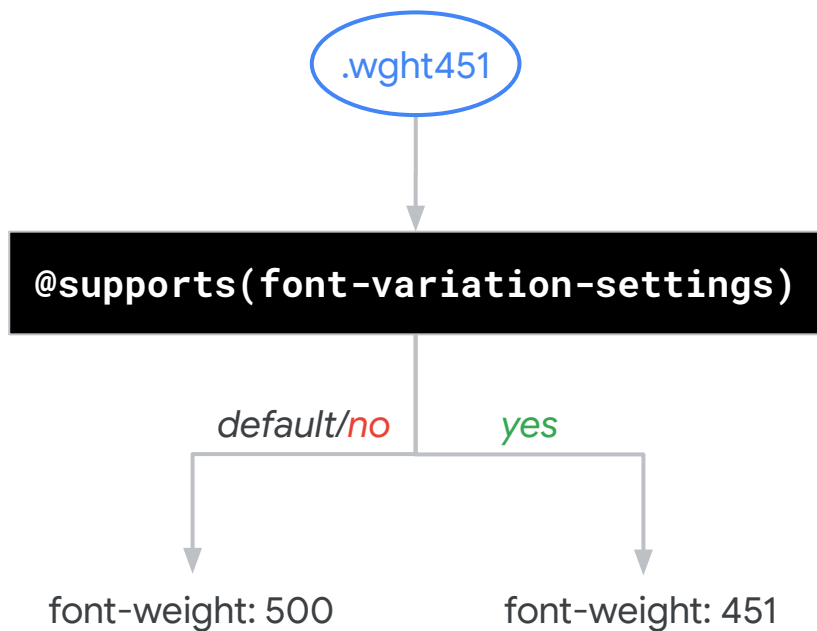
# Serving Legacy Browsers

.wght451

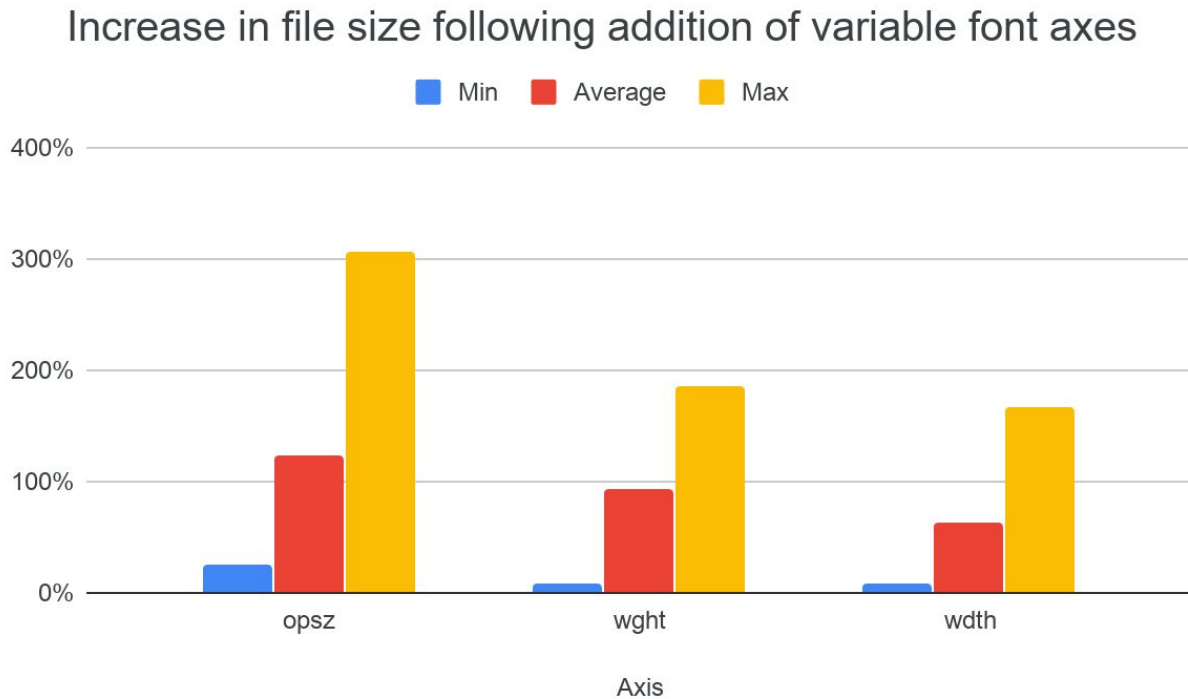
# Serving Legacy Browsers



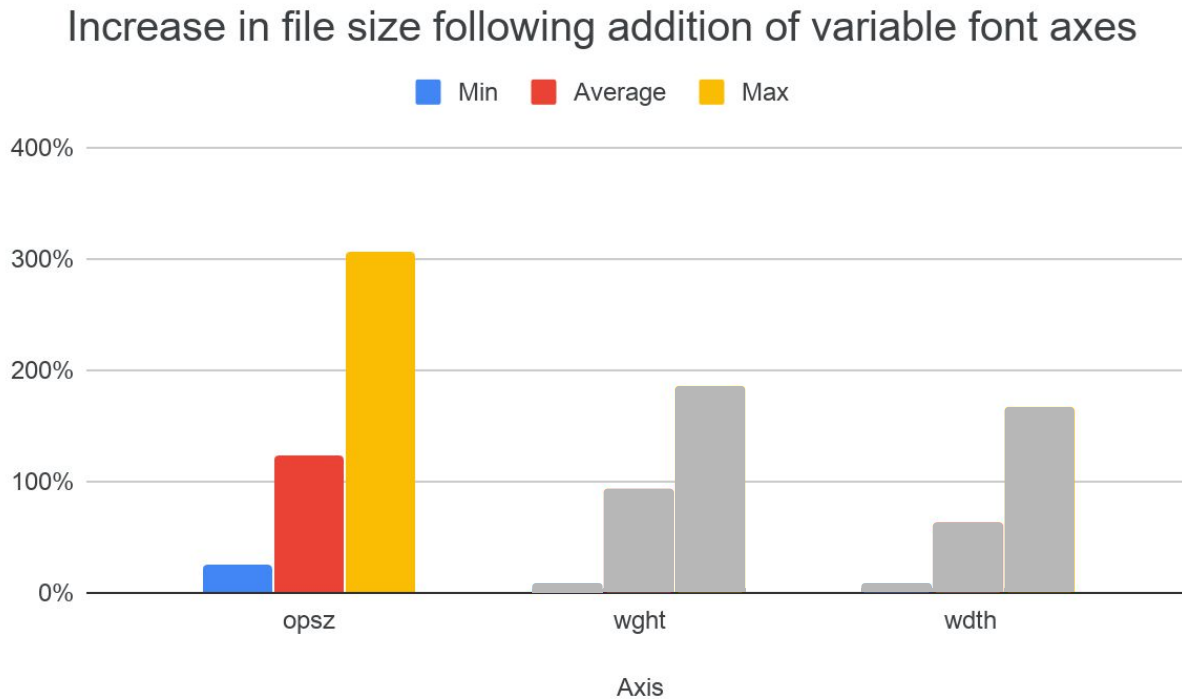
# Serving Legacy Browsers



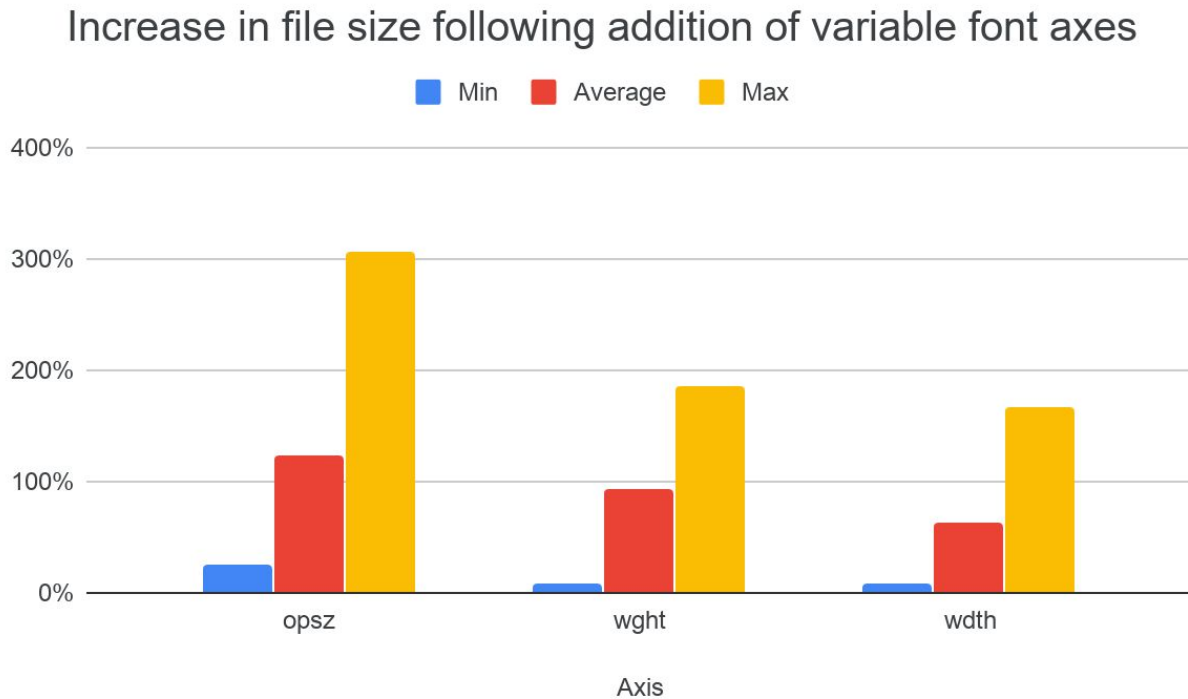
# Byte Savings



# Byte Savings

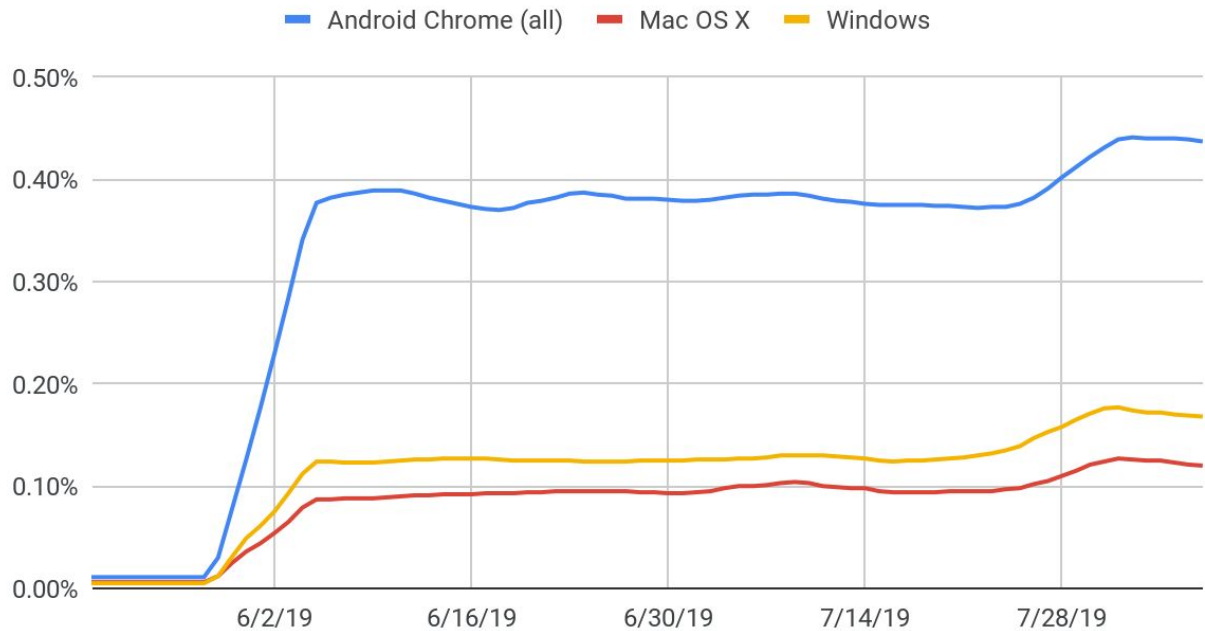


# Byte Savings



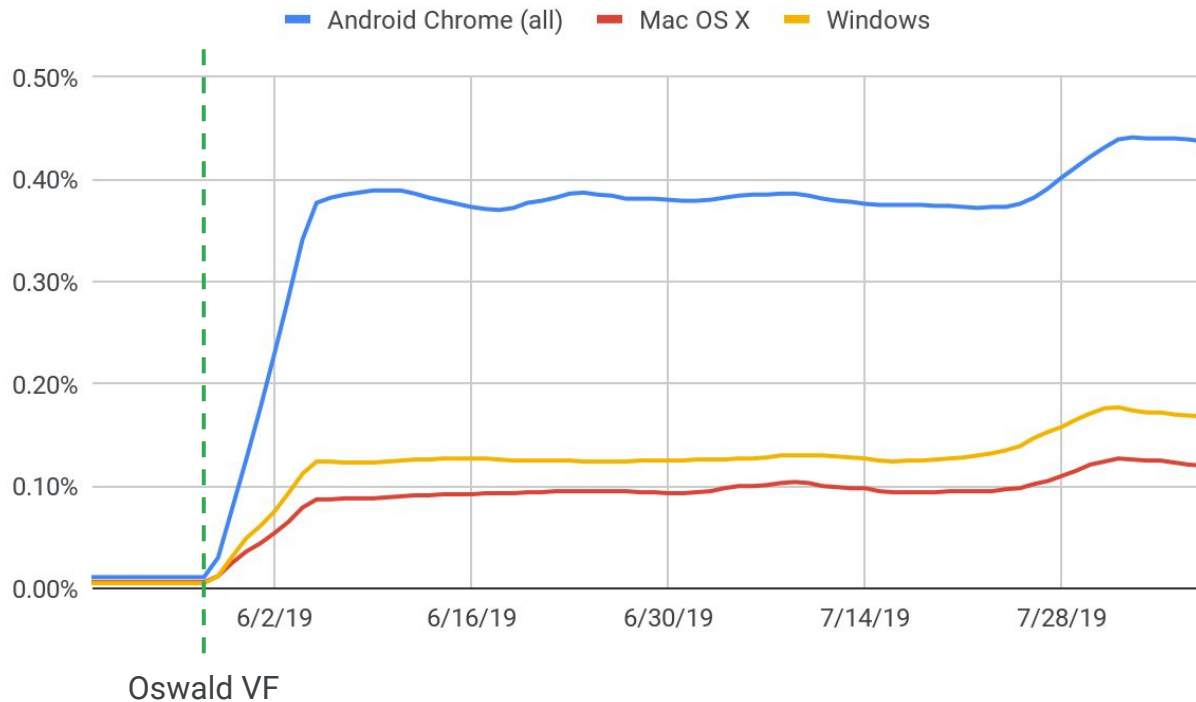
# Adoption

## Percent of font traffic that is variable on Chrome



# Adoption

## Percent of font traffic that is variable on Chrome





Oswald

148 MILLION per day

Fira Code

Literata

Crimson Pro

Kreon

Hepta Slab

Dosis

Comfortaa

Quicksand

Markazi Text

<https://developers.google.com/fonts/docs/css2>

# Variable API

```
/css2?family=<spec>[&family=<spec2>...]
```

```
spec: family_name:axis_tag_list@axis_tuple_list
```

# Variable API

In plain english:

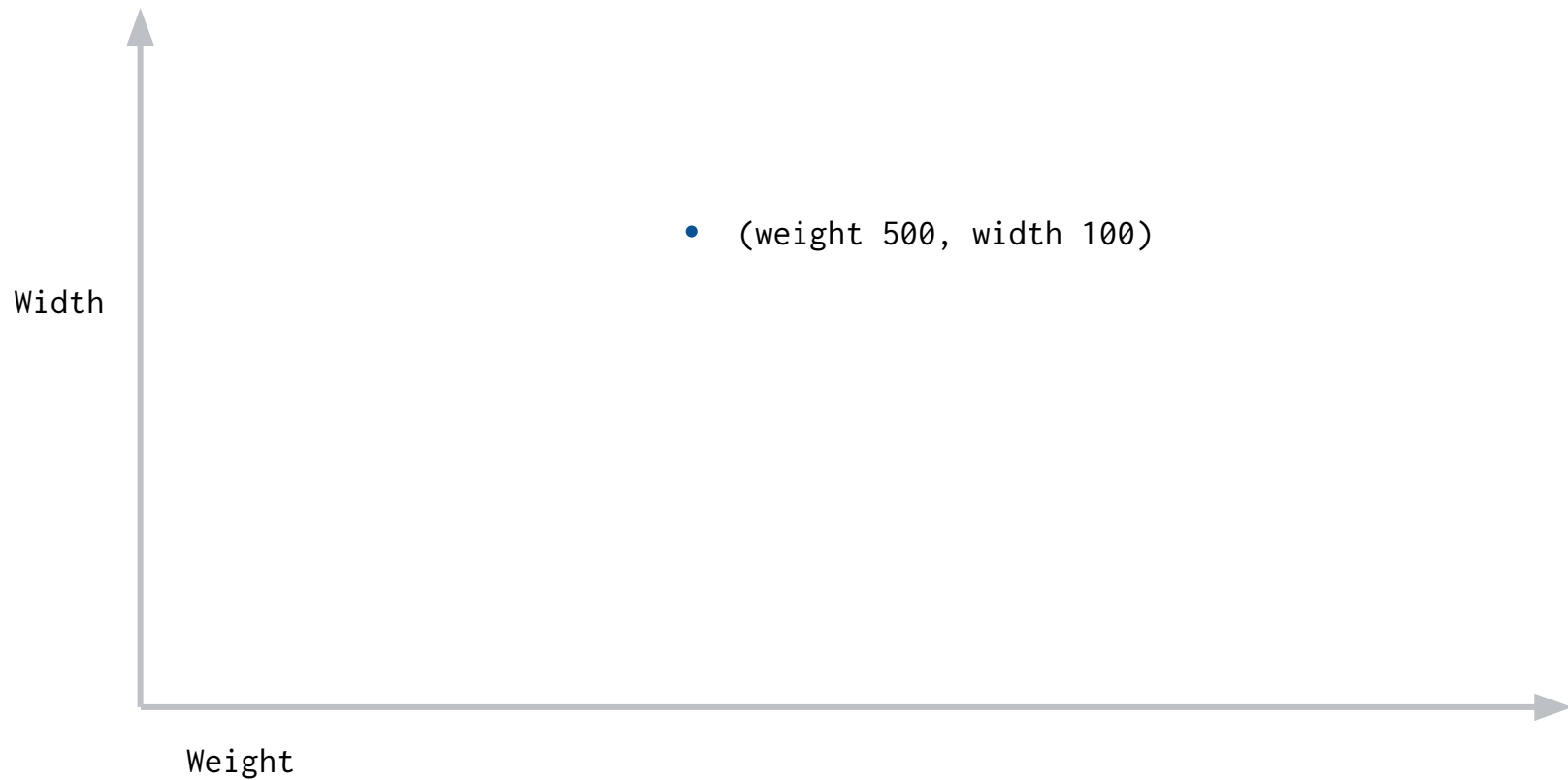
**For each family specify one or more regions of its axis space that you want to use**

# Example: a single point

Roboto+Extremo:wght@500

- Family Roboto+Extremo
- I want a font with `wght` at `500`
- Default position for any other axes

## Example: a single point



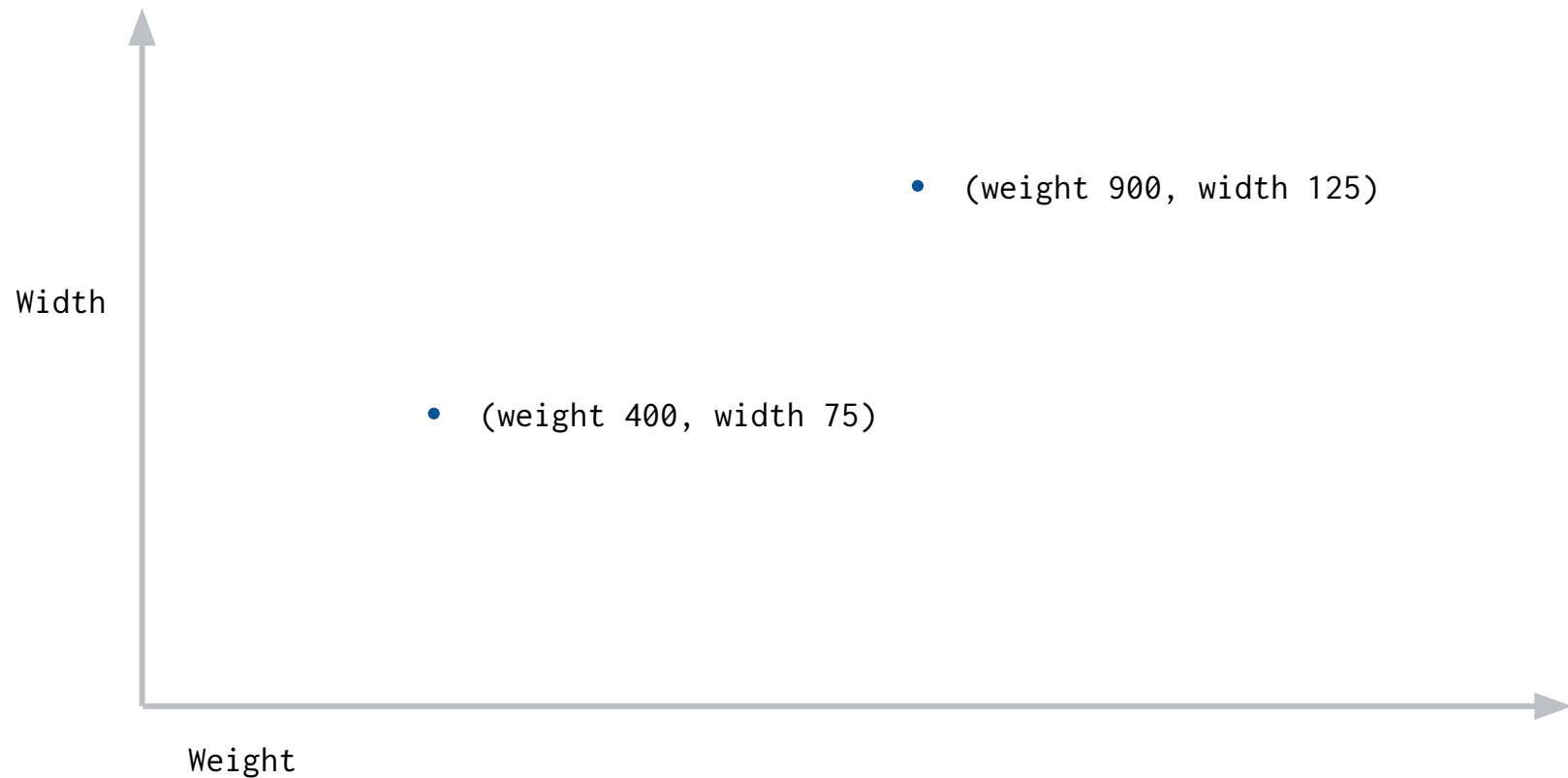
# Example: two points

Roboto+Extremo:width,wght@75,400;125,900

- I want a to use Roboto Extremo with:
  - Width at 75 and weight at 400
  - Width at 125 and weight at 900



## Example: two points

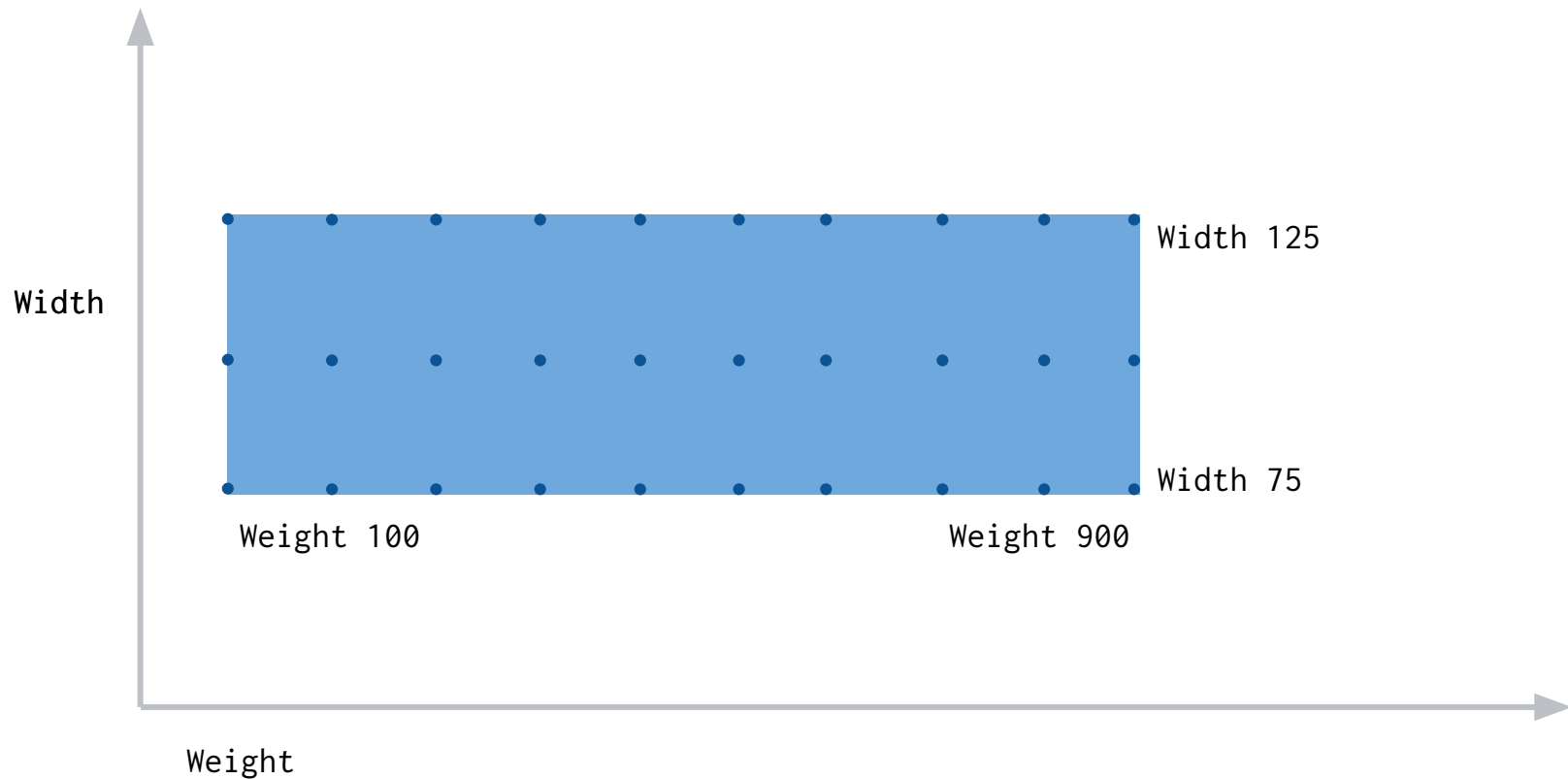


# Example: single region

Roboto+Extremo:width,wght@75..125;100..900

- I want a to use Roboto Extremo with:
  - A continuous `width` from `75` to `125`; and
  - A continuous `weight` from `100` to `900`

# Example: a region



# Web Font Woes

# Web Fonts Just Work, Right?

चंद्रमा पर छाई में गुम था । 🐱

b" b' 🐱

# Whole Font

Download this

```
/* slow & simple ftw? */  
@font-face  
  src: url(whole-font.woff2);  
  font-family: 'Merriweather';
```

# Whole Font

Download this →

```
/* slow & simple ftw? */  
@font-face  
  src: url(whole-font.woff2);  
  font-family: 'Merriweather';
```

If page uses this →

# Fragmented Font

```
/* cyrillic */  
@font-face  
  font-family: 'Merriweather';  
  src: url(cyrillic.woff2);  
  unicode-range: U+0400-045F;
```

Download this



```
/* latin */  
@font-face  
  font-family: 'Merriweather';  
  src: url(latin.woff2);  
  unicode-range: U+0000-00FF;
```



# Fragmented Font

```
/* cyrillic */  
@font-face  
  font-family: 'Merriweather';  
  src: url(cyrillic.woff2);  
  unicode-range: U+0400-045F;
```

Download this



If page uses this



```
/* latin */  
@font-face  
  font-family: 'Merriweather';  
  src: url(latin.woff2);  
  unicode-range: U+0000-00FF;
```

# Fragmented Font

```
/* cyrillic */  
@font-face  
  font-family: 'Merriweather';  
  src: url(cyrillic.woff2);  
  unicode-range: U+0400-045F;
```

Download this



If page uses this



```
/* latin */  
@font-face  
  font-family: 'Merriweather';  
  src: url(latin.woff2);  
  unicode-range: U+0000-00FF;
```

Download this



If page uses this



# Very Fragmented Font

```
/* Google Fonts CJK: 100+ @font-face rules */
```

```
/* part 1 of N */
```

```
@font-face
```

```
src: url(part1.woff2);
```

```
unicode-range: <chars in part 1>;
```

```
/* part 2 of N */
```

```
@font-face
```

```
src: url(part2.woff2);
```

```
unicode-range: <chars in part 2>;
```

```
...
```

```
/* part N of N */
```

```
@font-face
```

```
src: url(partN.woff3);
```

```
unicode-range: <chars in part N>;
```

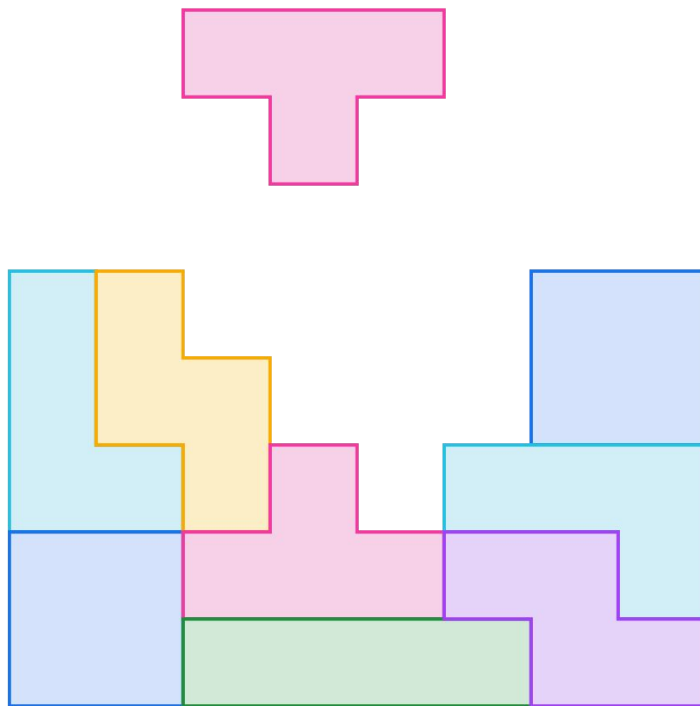




# Making It Better

# Progressive Font Enrichment

- Subset per page
- Merge into one font
- Built in to the browser



# Progressive Font Enrichment

**Page 1: "Meows"**

<b>M</b>
<b>e</b>
<b>o</b>
<b>s</b>
<b>w</b>



# Progressive Font Enrichment

Page 1: "Meows"

M
e
o
s
w

Page 2: "Awesome"

A
M
e
m
o
s
w
kern Aw

# Progressive Font Enrichment

Page 1: "Meows"

M
e
o
s
w

+

A
m
kern Aw

=

Page 2: "Awesome"

A
M
e
m
o
s
w
kern Aw

# Benefits

- Pay as you go
- Rendering fidelity
- Faster



[tinyurl.com/\*\*font-enrichment\*\*](https://tinyurl.com/font-enrichment)

# Demo

First page has text:

彼らの機器や装置はすべて生命体だ。

# Transfer Options

*NOTE: all options other than incremental transfer break layout features across segments. In reality this forces the use of large blocks in many scenarios (Arabic, Indic, many latin cases, etc).*

17 codepoints in Demo Content

## Options:

A) What Google Fonts would send today,  $\Sigma$  size 96.1 KB:

[11.9 KB slice-104] [12.3 KB slice-105] [10.7 KB slice-106] [10.8 KB slice-107] [10.4 KB slice-108] [10.3 KB slice-109] [7.9 KB slice-110] [21.8 KB slice-119]

B) woff2 of each segment,  $\Sigma$  segments 26.2 KB:

[26.2 KB woff2]

C) Incremental Transfer.  $\Sigma$  patches 26.2 KB:

[26.2 KB patch]

D) Optimal, woff2 of the exact subset:

[26.2 KB woff2]

## Demo Content

Clear

彼らの機器や装置はすべて生命体だ。

# Demo

Second page has text:

赤い炎が尖った翼の輪郭を浮かび上がらせた。

# Transfer Options

*NOTE: all options other than incremental transfer break layout features across segments. In reality this forces the use of large blocks in many scenarios (Arabic, Indic, many latin cases, etc).*

34 codepoints (17 + 17) in Demo Content

## Options:

A) What Google Fonts would send today,  $\Sigma$  size 182.7 KB:

[11.7 K... [11.9 K... [12.3 K... [11.4 K... [10.7 ... [10.8 ... [10.4 ... [10.3 ... [7.9... [21.8 KB slice-119] [13.2 KB... [13.6 KB ... [12.2 K... [11.9 K... [12.7 K...

B) woff2 of each segment,  $\Sigma$  segments 54.3 KB:

[26.2 KB woff2] [28.1 KB woff2]

C) Incremental Transfer.  $\Sigma$  patches 35.2 KB:

[26.2 KB patch] [9.1 ...]

D) Optimal, woff2 of the exact subset:

[31.6 KB woff2]

# Demo Content

Clear

赤い炎が尖った翼の輪郭を浮かび上がらせた。  
彼らの機器や装置はすべて生命体だ。



# Transfer Options

*NOTE: all options other than incremental transfer break layout features across segments. In reality this forces the use of large blocks in many scenarios (Arabic, Indic, many latin cases, etc).*

34 codepoints (17 + 17) in Demo Content

## Options:

A) What Google Fonts would send today,  $\Sigma$  size 182.7 KB:

[11.7 K... [11.9 K... [12.3 K... [11.4 K... [10.7 ... [10.8 ... [10.4 ... [10.3 ... [7.9... [21.8 KB slice-119] [13.2 KB... [13.6 KB ... [12.2 K... [11.9 K... [12.7 K...

B) woff2 of each segment,  $\Sigma$  segments 54.3 KB:

[26.2 KB woff2] [28.1 KB woff2]

C) Incremental Transfer.  $\Sigma$  patches 35.2 KB:

[26.2 KB patch] [9.1 ...]

D) Optimal, woff2 of the exact subset:

[31.6 KB woff2]

## Demo Content

Clear

赤い炎が尖った翼の輪郭を浮かび上がらせた。  
彼らの機器や装置はすべて生命体だ。

# Transfer Options

*NOTE: all options other than incremental transfer break layout features across segments. In reality this forces the use of large blocks in many scenarios (Arabic, Indic, many latin cases, etc).*

34 codepoints (17 + 17) in Demo Content

## Options:

A) What Google Fonts would send today,  $\Sigma$  size 182.7 KB:

[11.7 K... [11.9 K... [12.3 K... [11.4 K... [10.7 ... [10.8 ... [10.4 ... [10.3 ... [7.9... [21.8 KB slice-119] [13.2 KB... [13.6 KB ... [12.2 K... [11.9 K... [12.7 K...

B) woff2 of each segment,  $\Sigma$  segments 54.3 KB:

[26.2 KB woff2] [28.1 KB woff2]

C) Incremental Transfer.  $\Sigma$  patches 35.2 KB:

[26.2 KB patch] [9.1 ...]

D) Optimal, woff2 of the exact subset:

[31.6 KB woff2]

## Demo Content

Clear

赤い炎が尖った翼の輪郭を浮かび上がらせた。  
彼らの機器や装置はすべて生命体だ。

# Transfer Options

*NOTE: all options other than incremental transfer break layout features across segments. In reality this forces the use of large blocks in many scenarios (Arabic, Indic, many latin cases, etc).*

34 codepoints (17 + 17) in Demo Content

## Options:

A) What Google Fonts would send today,  $\Sigma$  size 182.7 KB:

[11.7 K... [11.9 K... [12.3 K... [11.4 K... [10.7 ... [10.8 ... [10.4 ... [10.3 ... [7.9... [21.8 KB slice-119] [13.2 KB... [13.6 KB ... [12.2 K... [11.9 K... [12.7 K...

B) woff2 of each segment,  $\Sigma$  segments 54.3 KB:

[26.2 KB woff2] [28.1 KB woff2]

C) Incremental Transfer.  $\Sigma$  patches 35.2 KB:

[26.2 KB patch] [9.1 ...]

D) Optimal, woff2 of the exact subset:

[31.6 KB woff2]

## Demo Content

Clear

赤い炎が尖った翼の輪郭を浮かび上がらせた。  
彼らの機器や装置はすべて生命体だ。

# Demo

Third page has text:

気が付くとすでに地球を飛び立っていた。

# Transfer Options

*NOTE: all options other than incremental transfer break layout features across segments. In reality this forces the use of large blocks in many scenarios (Arabic, Indic, many latin cases, etc).*

44 codepoints (17 + 17 + 10) in Demo Content

## Options:

A) What Google Fonts would send today,  $\Sigma$  size 192.0 KB:

[11.7 ...] [11.9 K...] [12.3 K...] [11.4 ...] [10.7 ...] [10.8 ...] [9.2 ...] [10.4 ...] [10.3 ...] [7....] [21.8 KB slice-1...] [13.2 K...] [13.6 KB...] [12.2 K...] [11.9 K...] [12.7 K...]

B) woff2 of each segment,  $\Sigma$  segments 82.5 KB:

[26.2 KB woff2] [28.1 KB woff2] [28.3 KB woff2]

C) Incremental Transfer.  $\Sigma$  patches 42.8 KB:

[26.2 KB patch] [9.1 ...] [7....]

D) Optimal, woff2 of the exact subset:

[35.4 KB woff2]

# Demo Content

Clear

気が付くとすでに地球を飛び立っていた。  
赤い炎が尖った翼の輪郭を浮かび上がらせた。  
彼らの機器や装置はすべて生命体だ。

# What Scripts Benefit

## What Scripts Benefit

The spectacle before us was indeed sublime.  
המראה שלפנינו אכן היה נשגב.

كان المشهد أمامنا سامير.  
हमारे सामने का नज़ारा वाकई उत्कृष्ट था ।

彼らの機器や装置はすべて生命体だ。  
그들의 장비와 기구는 모두 살아 있다.

## Simple Scripts

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## Complex Scripts

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हमारे सामने का नज़ारा वाकई उत्कृष्ट था ।

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그들의 장비와 기구는 모두 살아 있다.

## Large Scripts

The spectacle before us was indeed sublime.  
המראה שלפנינו אכן היה נשגב.

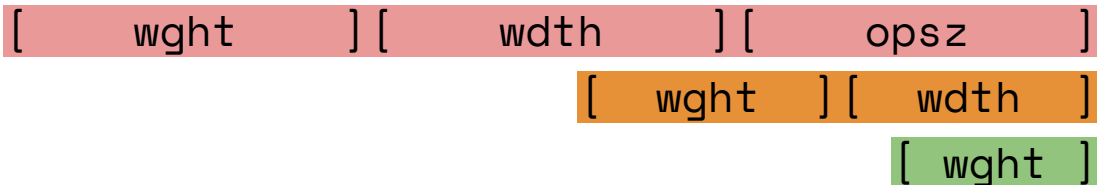
كان المشهد أمامنا سامير.

हमारे सामने का नज़ारा वाकई उत्कृष्ट था ।

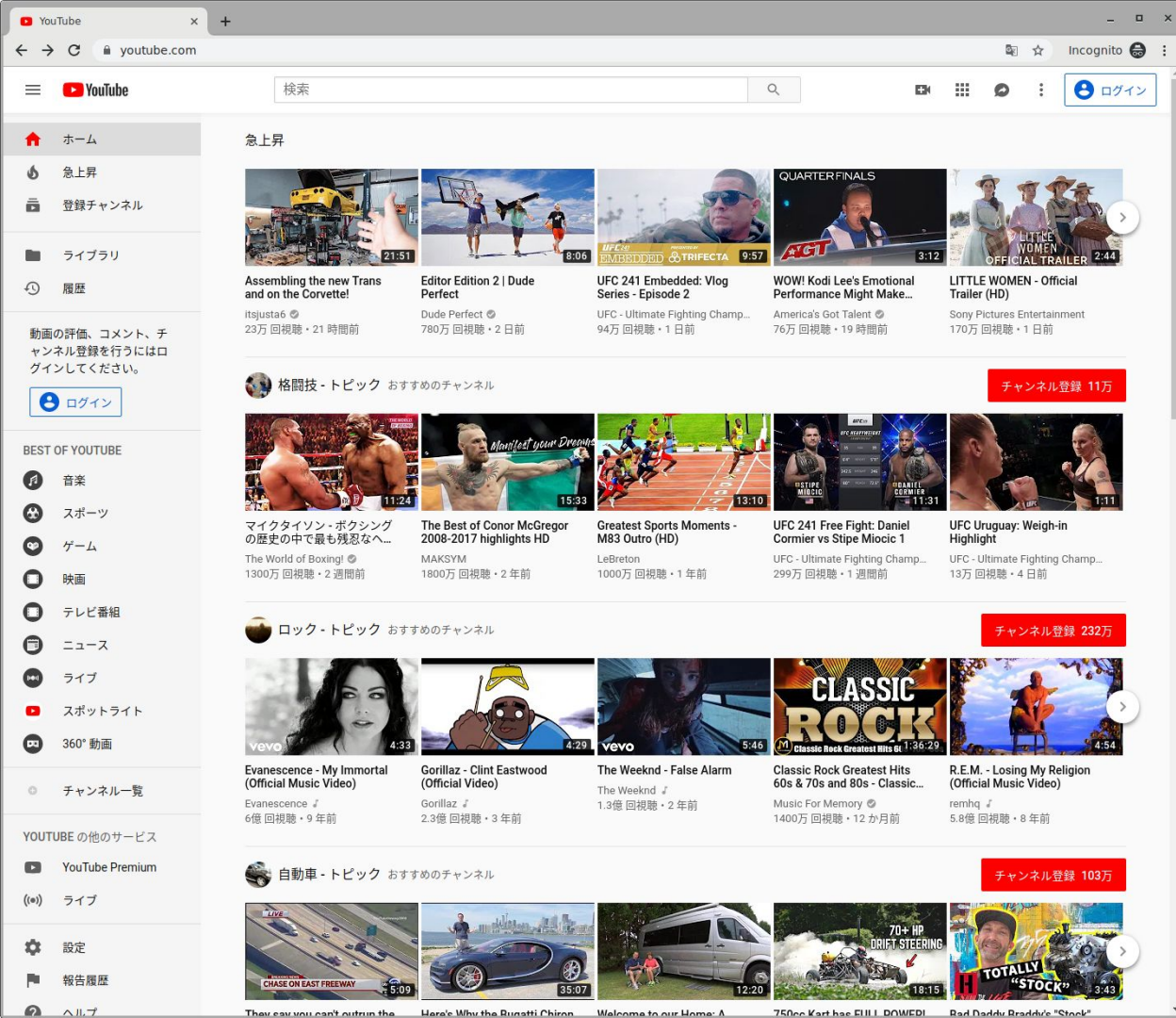
彼らの機器や装置はすべて生命体だ。

그들의 장비와 기구는 모두 살아 있다.

# Variable Fonts



- Web usage is picking up!
- "Variable fonts are smaller" oversimplifies
- Progressive enrichment to the rescue?
  - Only transfer what we use



Noto Sans JP

Roboto Regular

Roboto Medium

YouTube Sans

# Current Status

# W3C Web Fonts Working Group

- Created the WOFF and WOFF2
- Cross industry collaboration
- Participants from many companies



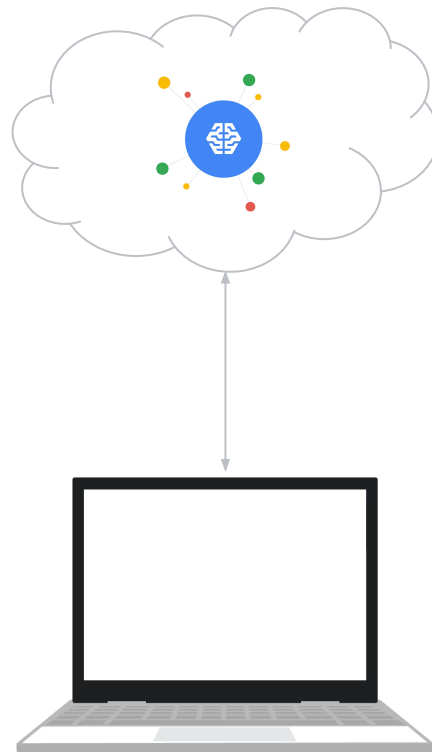
# W3C Web Fonts Working Group

- Rechartered for PFE
- Two approaches being considered



# Smart Server, Simple Client

- Server handles complexity
- Client just applies patches





# Smart Server, Simple Client

## Client Has

M
e
o
s
w

## Client Wants

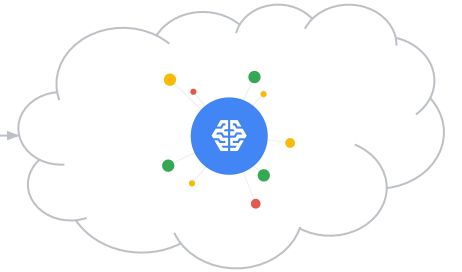
A
M
e
m
o
s
w
kern Aw

# Smart Server, Simple Client



I have: MeosW

Need additional: Am



# Smart Server, Simple Client

Server computes 2 subsets:

**Client's Desired State**

A
M
e
m
o
s
w
kern Aw

**Client's Current State**

M
e
o
s
w

# Smart Server, Simple Client

Then computes a binary diff

**Client's Desired State**

A
M
e
m
o
s
w
kern Aw

-

**Client's Current State**

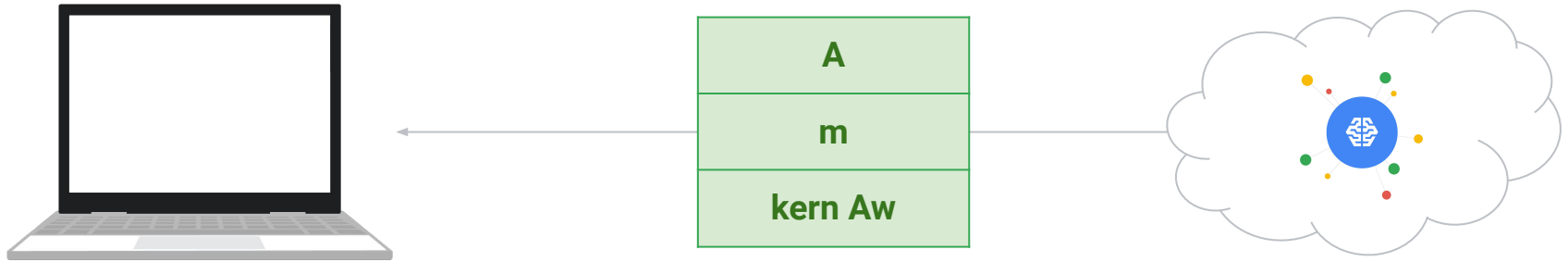
M
e
o
s
w

=

**Binary Patch**

A
m
kern Aw

# Smart Server, Simple Client



# Smart Server, Simple Client

Client's Font

M
e
o
s
w

+

Patch from Server

A
m
kern Aw

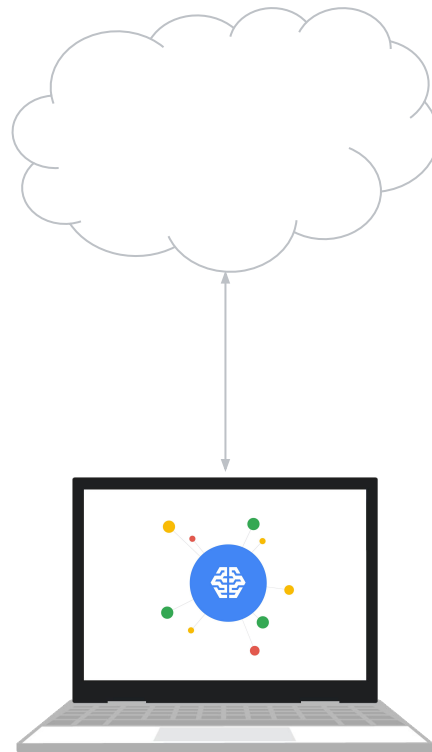
=

Desired Subset

A
M
e
m
o
s
w
kern Aw

# Simple Server, Smart Client

- Complex client
- Standard HTTP server
- HTTP range requests

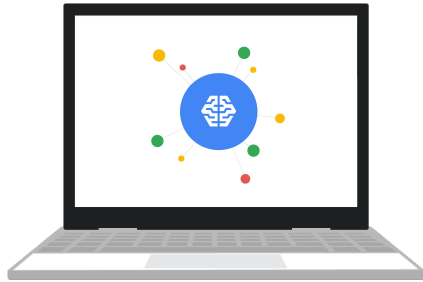


# Simple Server, Smart Client

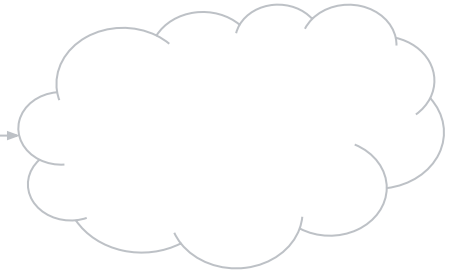
<b>Table directory</b>
<b>loca</b>
<b>shaping</b>
a
b
c
d
e
f



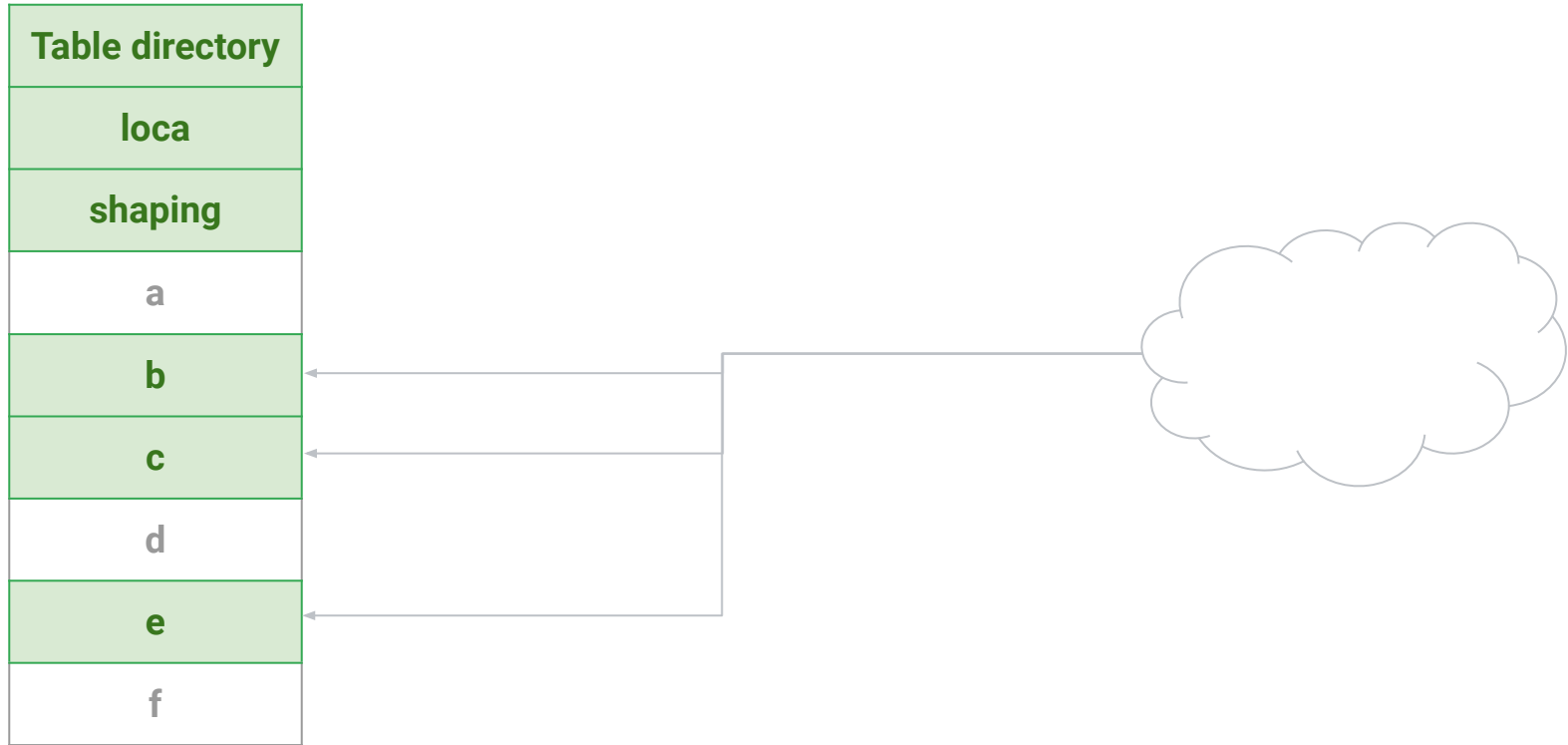
# Simple Server, Smart Client



Ranges: 201-456, ...



# Simple Server, Smart Client



# Trade Offs

## Smart Server

- Easy client implementation
- Ongoing optimization

## Smart Client

- Standard HTTP server
- Easy adoption
- Easy self hosting

# Trade Offs

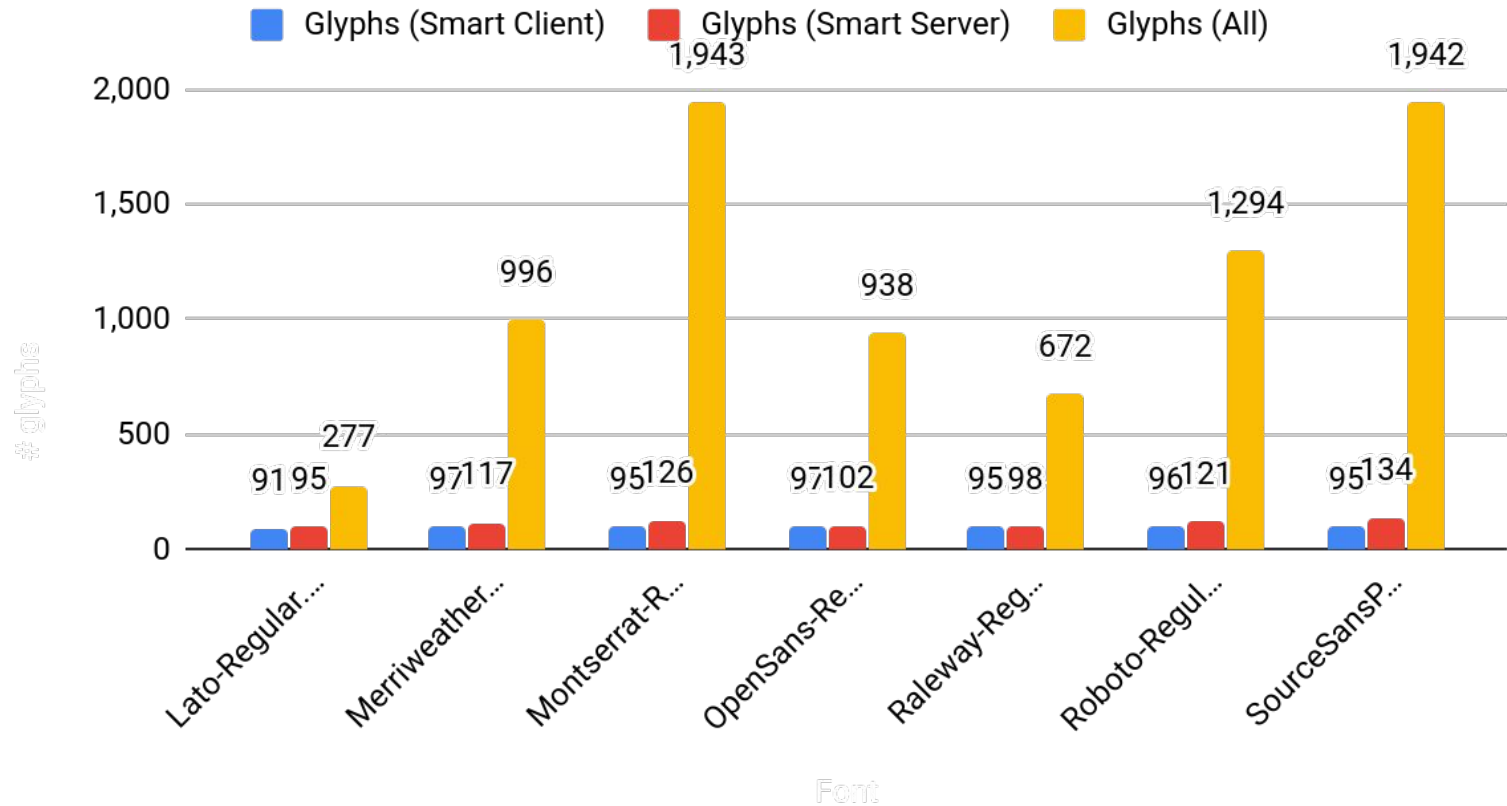
## Smart Server

- Works with codepoints
- Over delivers glyphs
- Subsets all tables

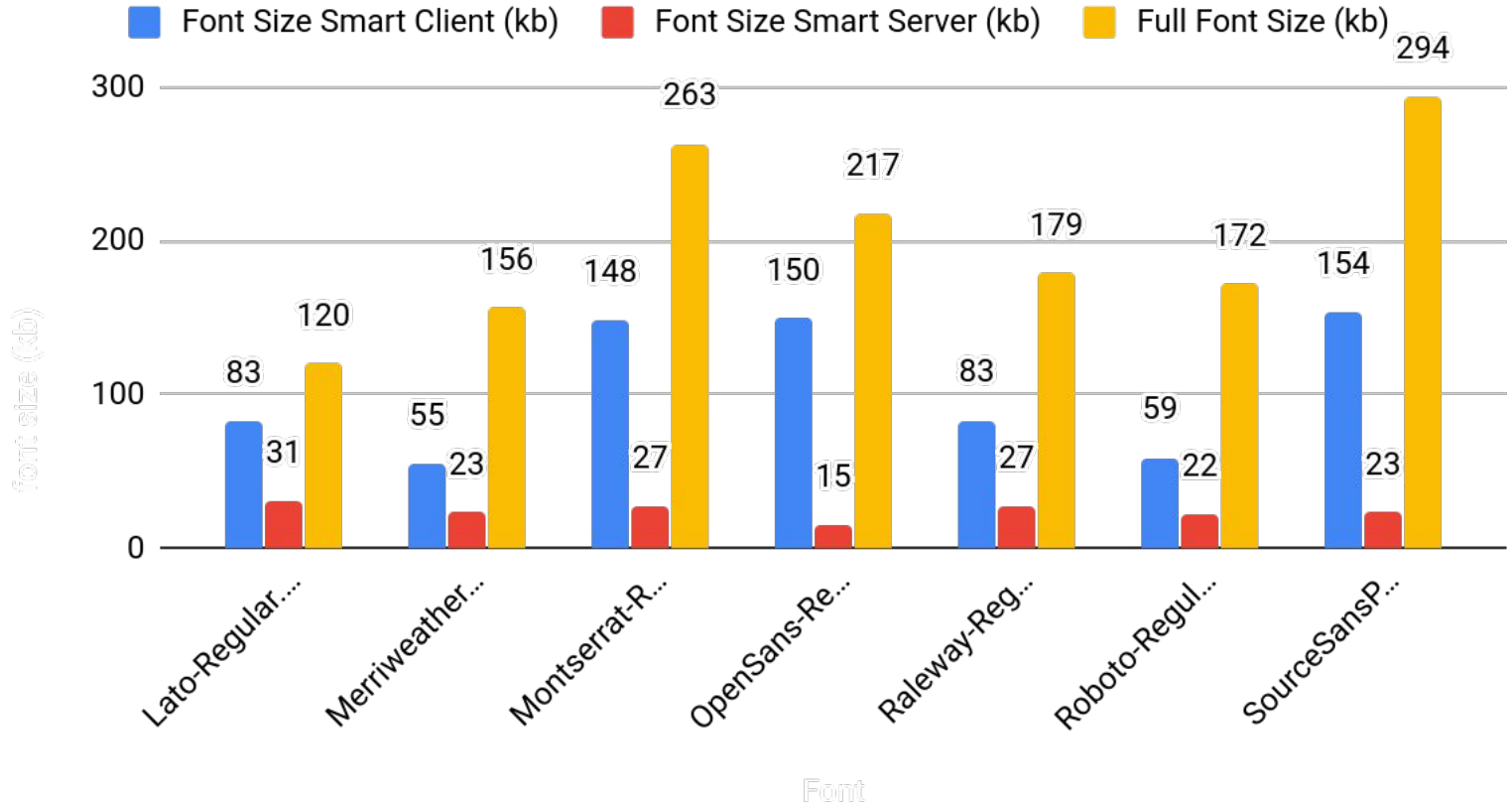
## Smart Client

- Works with glyph IDs
- Only subsets glyf

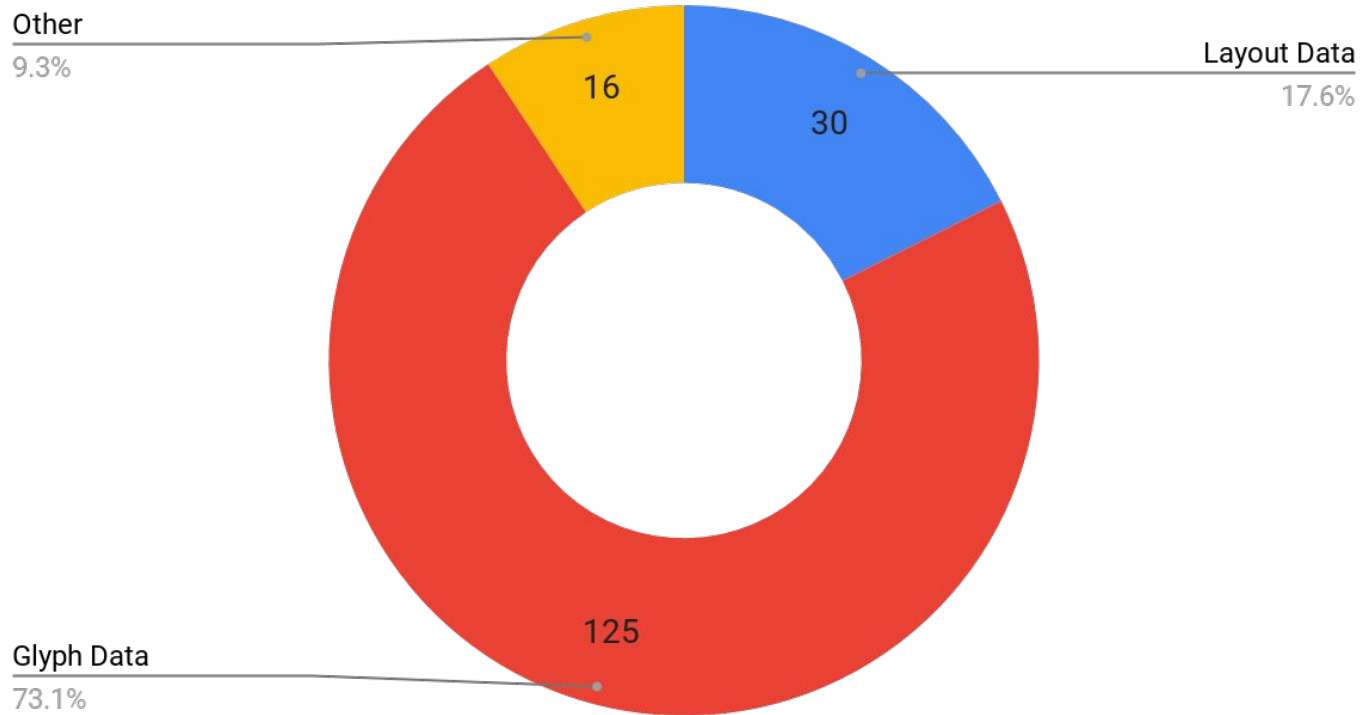
# Glyphs Needed by Method (English)



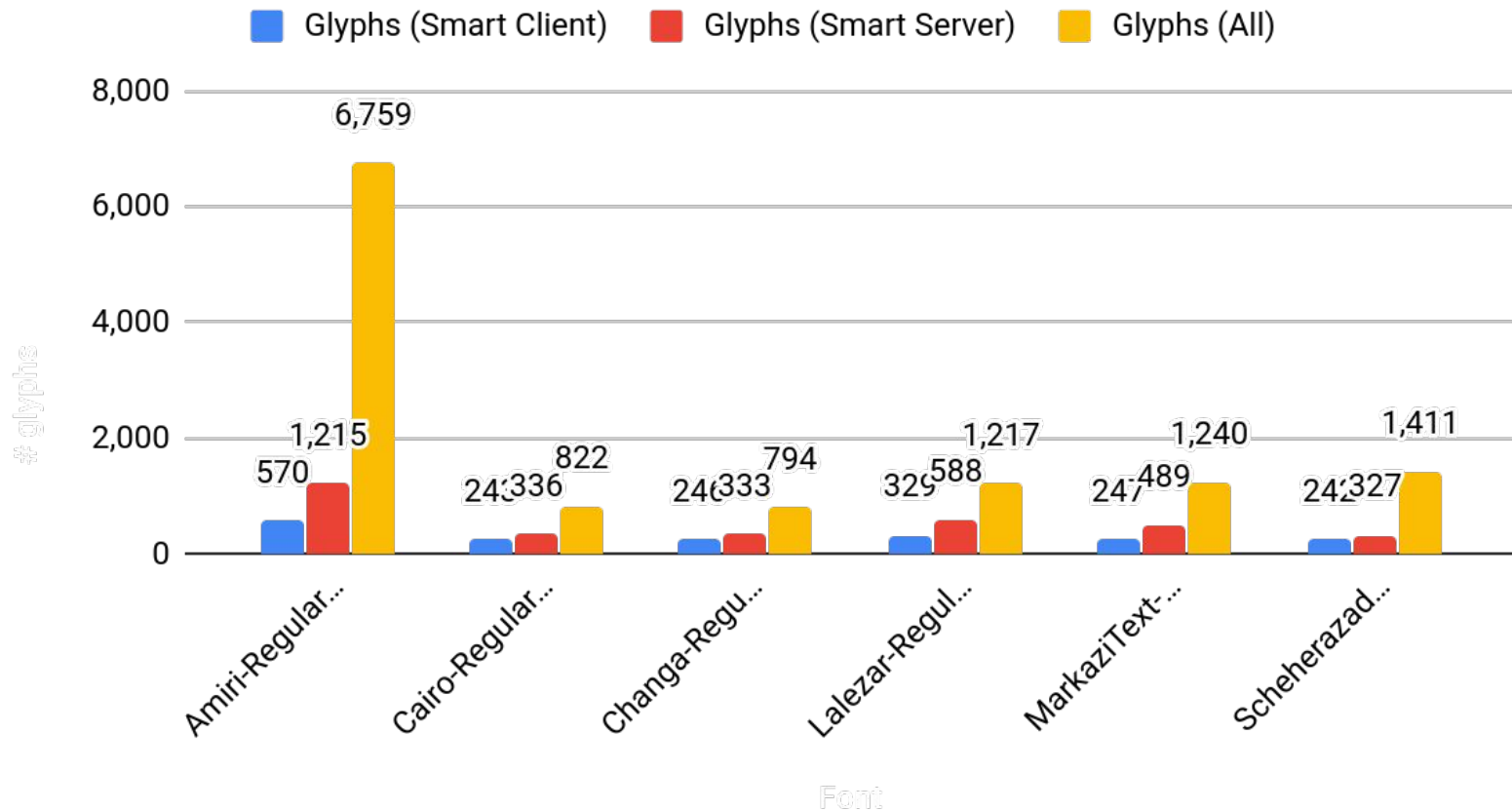
# Final Font Size by Method (English)



## Table Sizes for Roboto (kb)

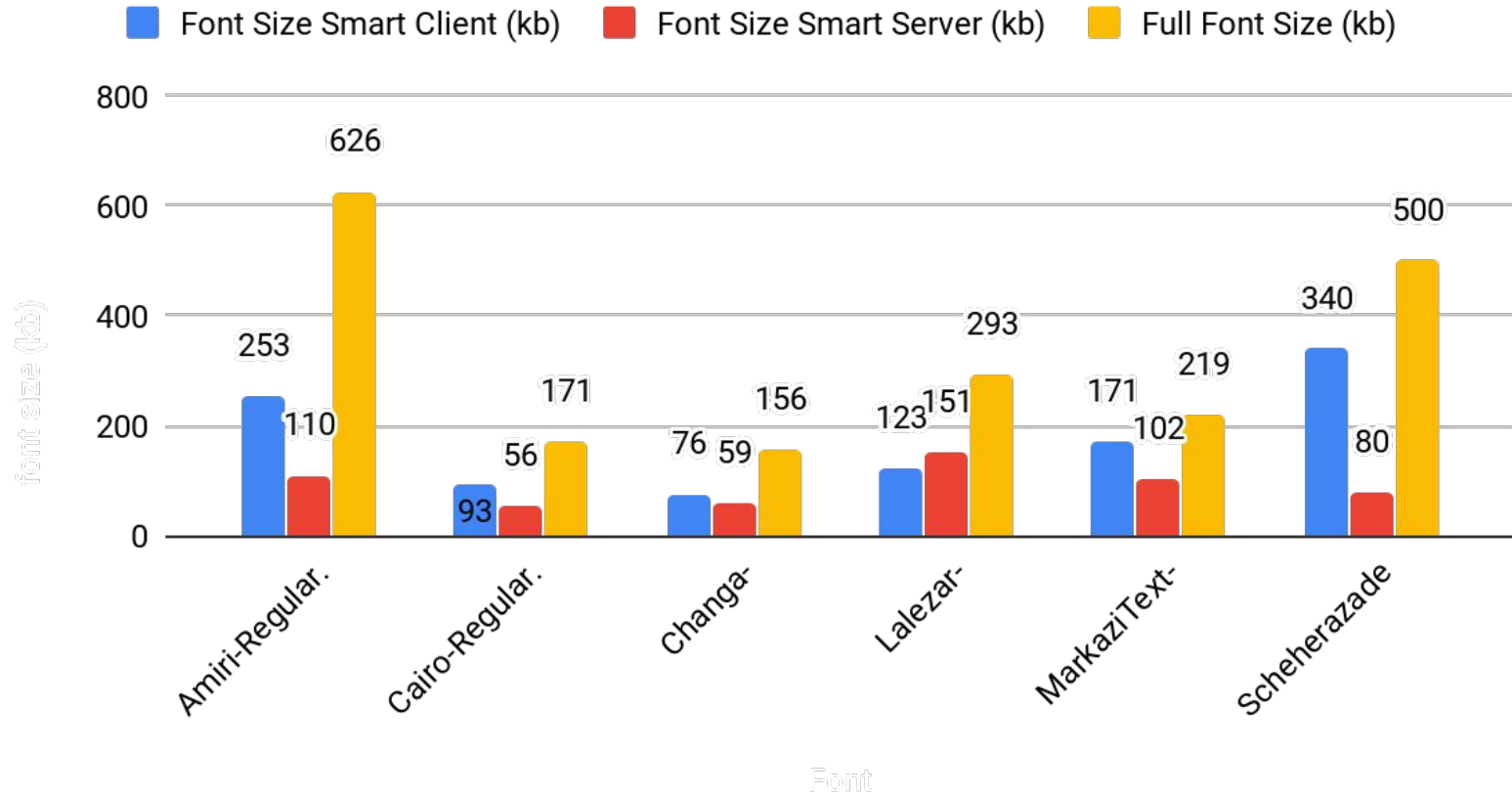


# Glyphs Needed by Method (Arabic)

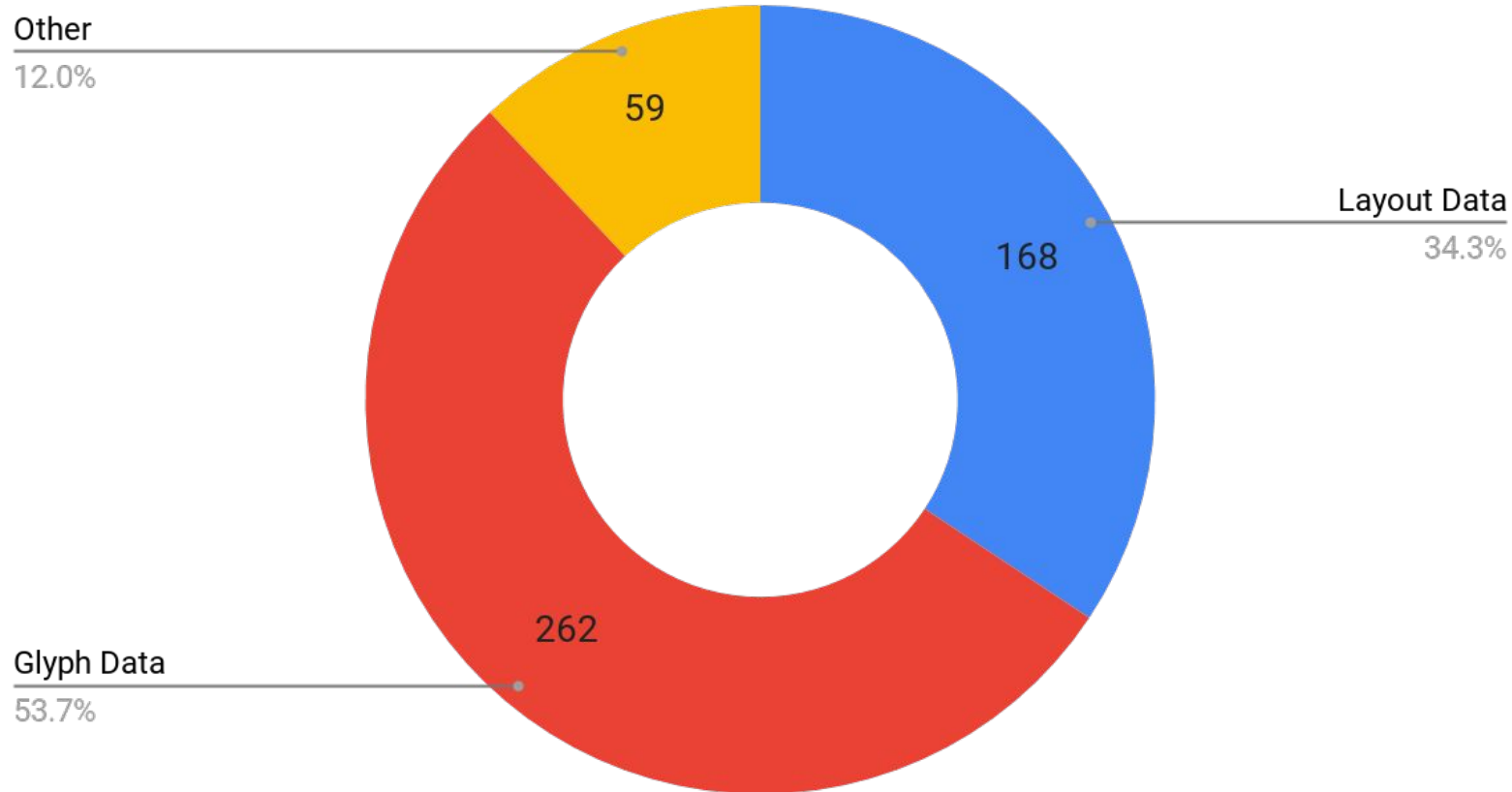




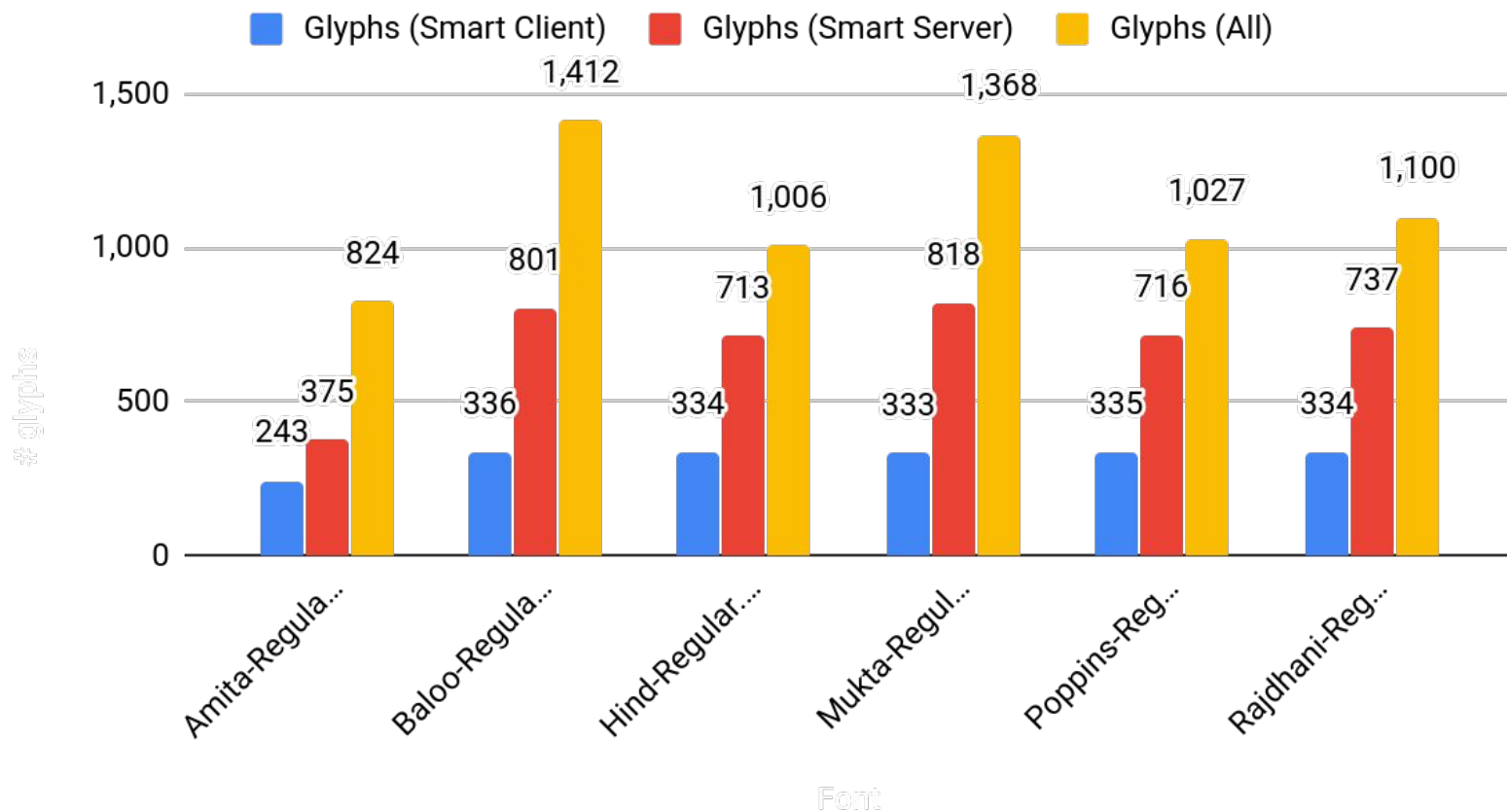
# Final Font Size by Method (Arabic)



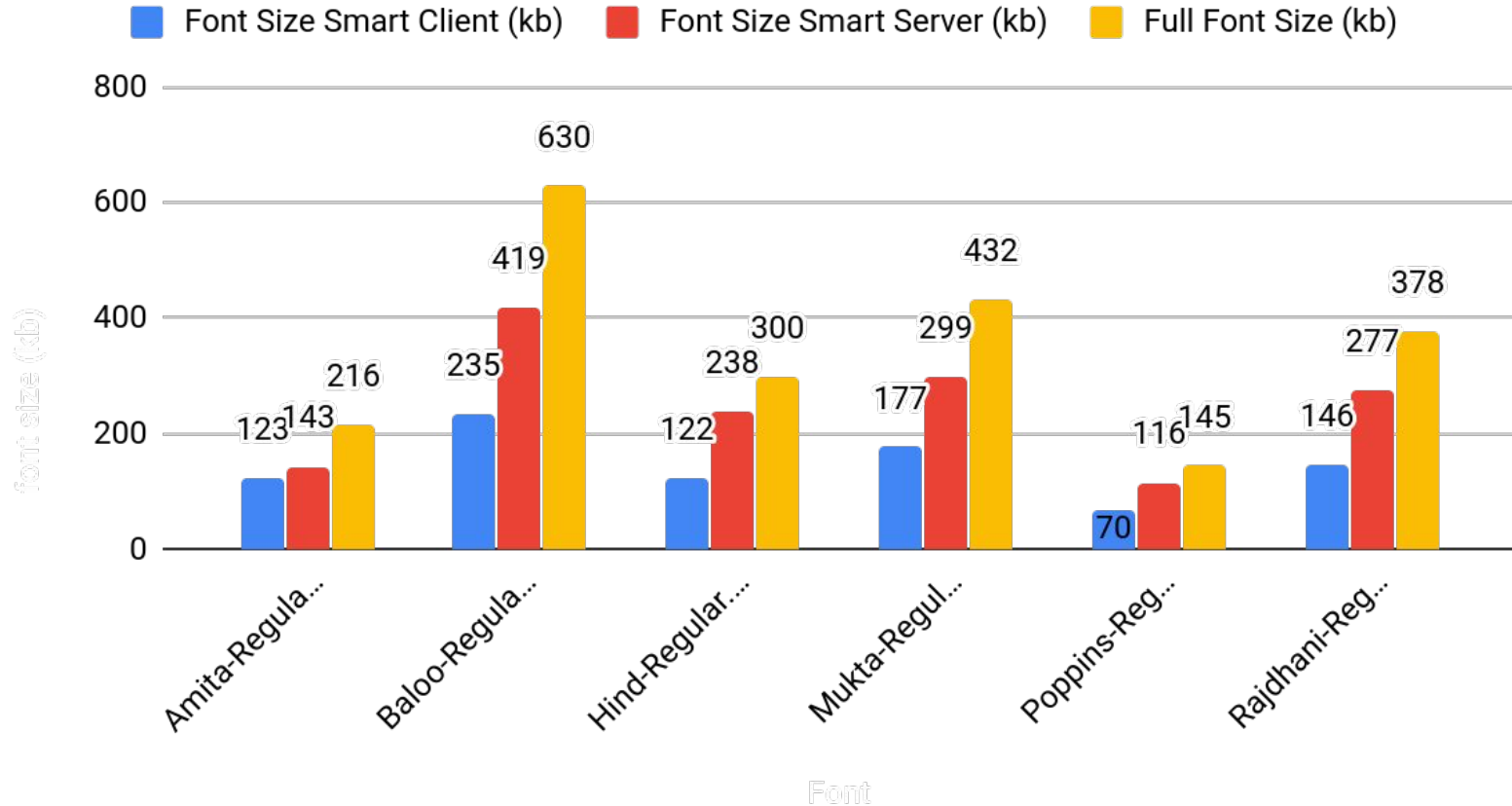
## Table Sizes for Amiri (kb)



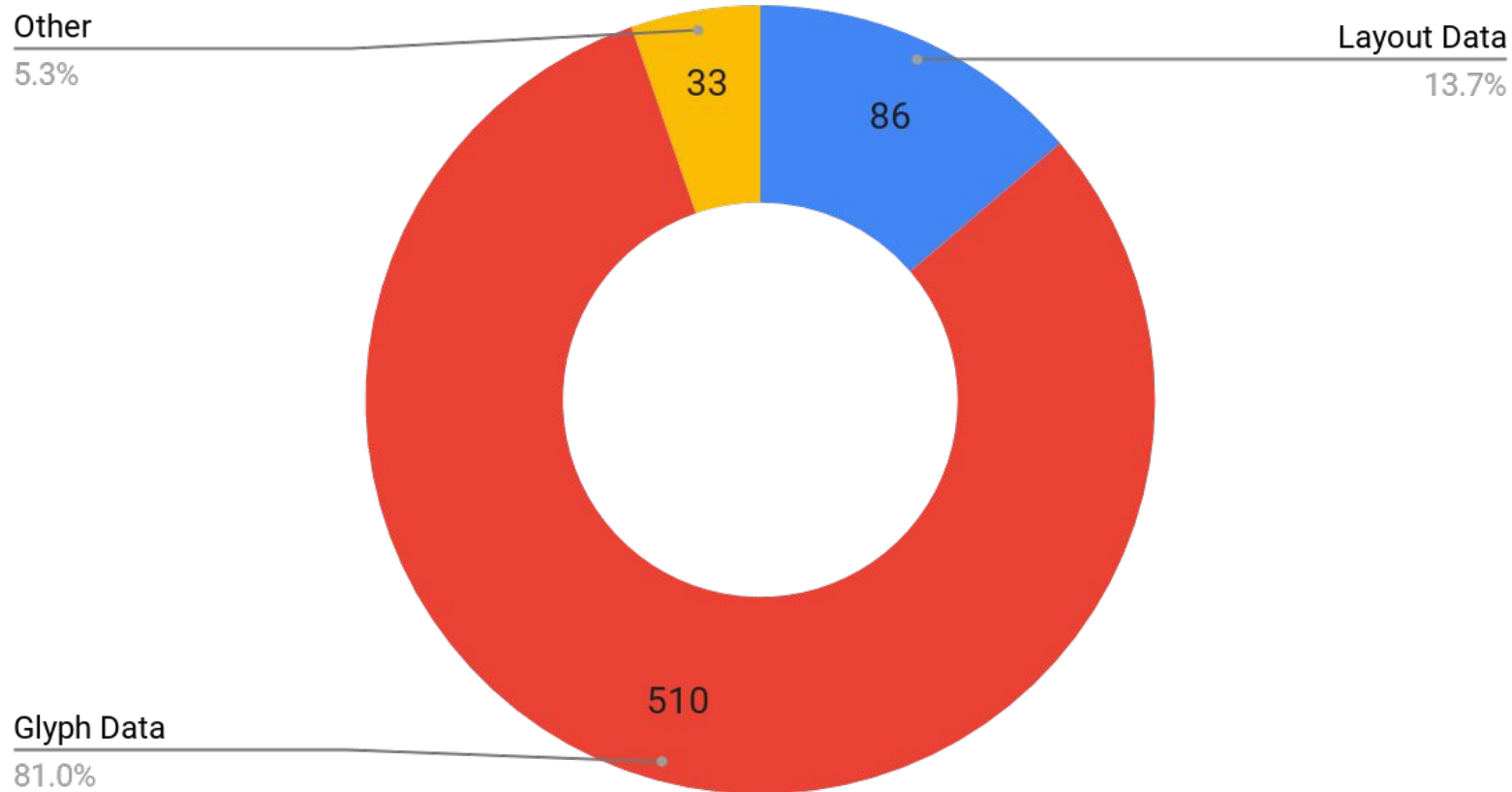
# Glyphs Needed by Method (Devanagari)



# Final Font Size by Method (Devanagari)



## Table Sizes for Baloo (kb)



# Competition Is Good

- Both are promising
- Test to find the best
- Share ideas



# Evaluating Proposals

# Comparing Proposals

## We want

- Rendering fidelity
- Fast page loads

## For

- Any page
- Any script
- Any network





# Simulation

## Simulate realistic

- Network conditions
- User browsing

Compare, pick a winner!



# Wanted: Browsing Dataset

We don't HAVE a dataset of  
browsing sessions

Working on creating a realistic  
dataset and simulation rig

THEN we can pick a winner!



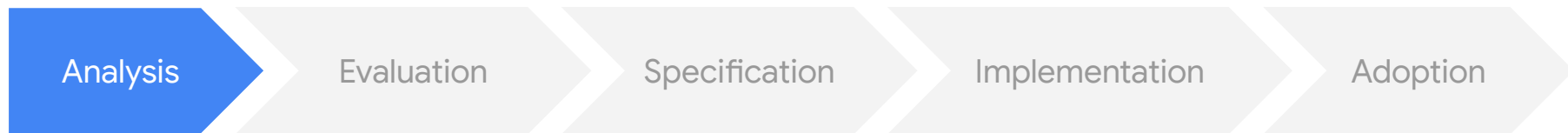


# Roadmap

# Roadmap

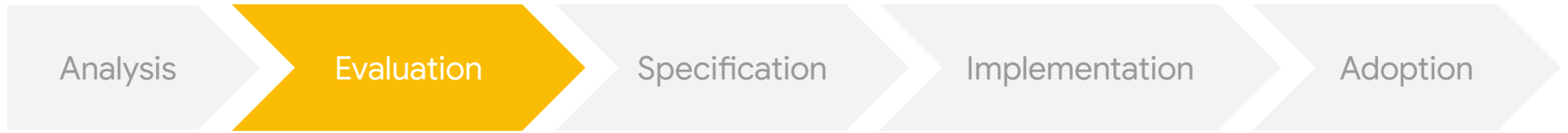


# Analysis



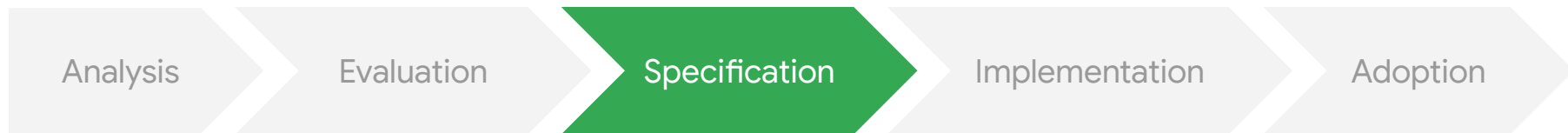
- Proposals
- Evaluation Framework
- Gather data and test

# Evaluation



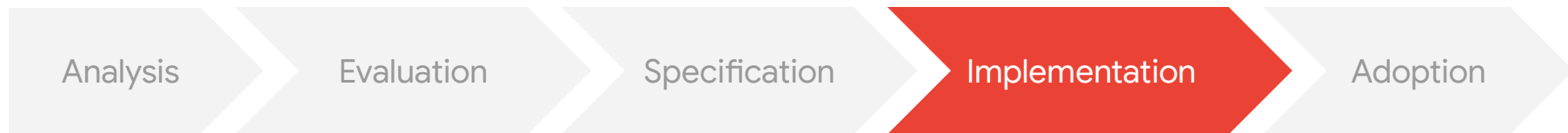
- Evaluation report
- Recommend path forward

# Specification



- Formal specification
- Enables interoperability

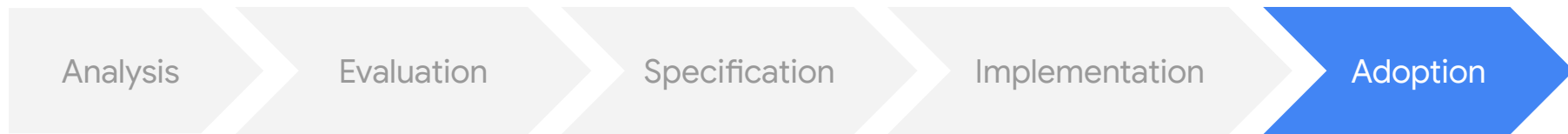
# Implementation



- Two implementations
- Built from the spec



# Adoption



- Shipped in browsers
- Deployed by font hosts

# Thank you

`developers.google.com/fonts/docs/css2`

`tinyurl.com/font-enrichment`