

# [320] Web 5: A/B Testing

Tyler Caraza-Harter

# Source for Examples/Lessons

[Ronny Kohavi](#) Keynote Talk at KDD conference (Knowledge Discovery and Data Mining)

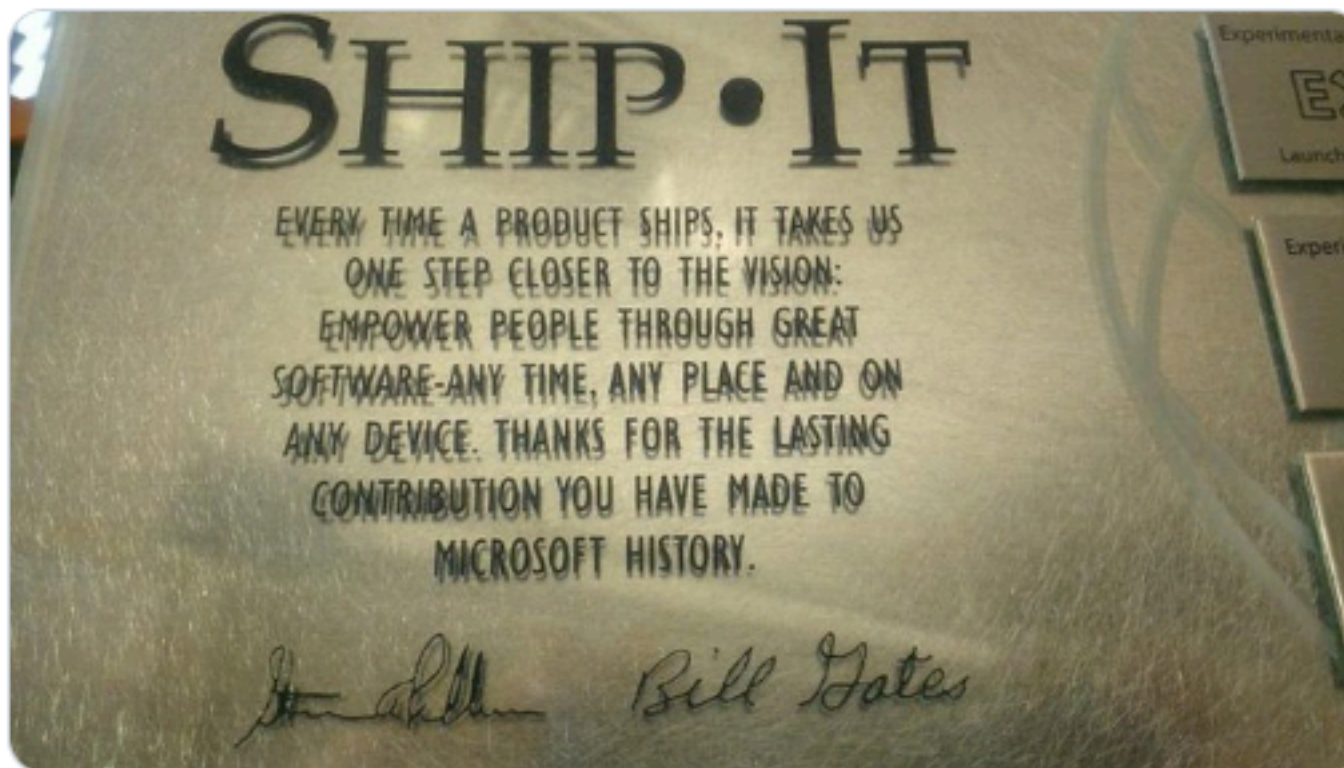
**Title:** Online Controlled Experiments: Lessons from Running A/B/n Tests for 12 years

**Video:** <https://exp-platform.com/kdd2015keynotekohavi/>



**Ronny Kohavi** @ronnyk · Nov 7, 2014

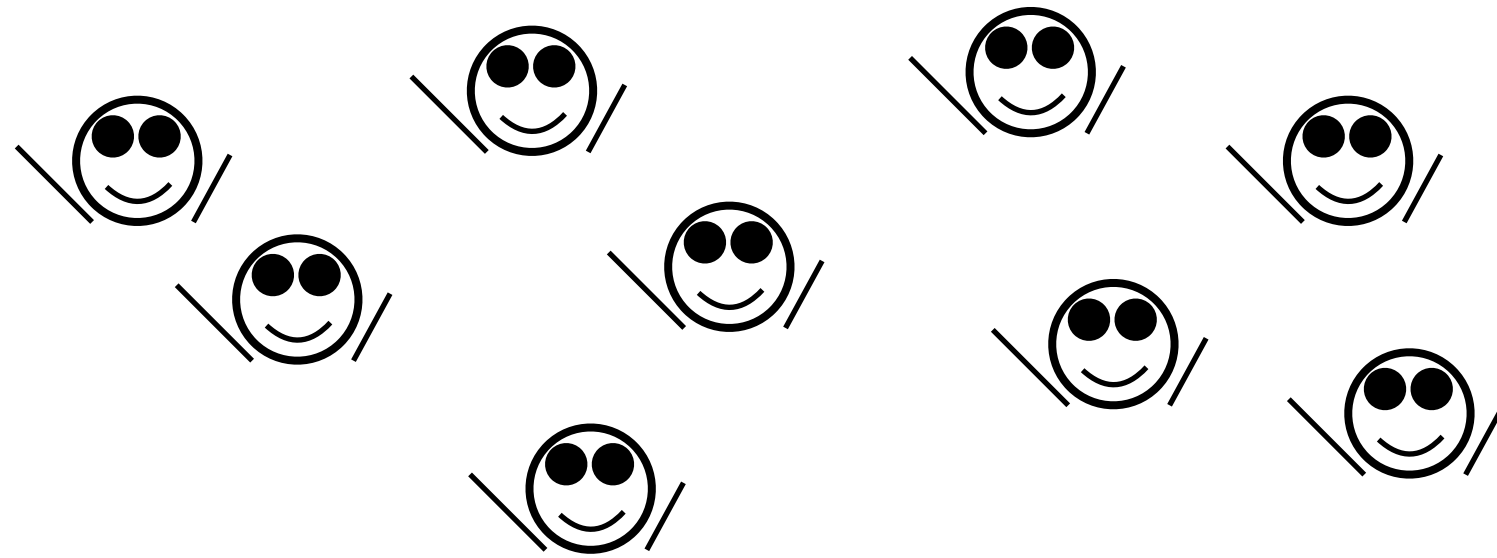
Microsoft stopped ship-it-awards today! With [#abtesting](#), it's about user-impact; NOT shipping is often better!



# Experiment Design:

## Does Coffee Improve Programming Ability?

programmers:

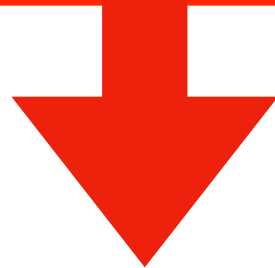
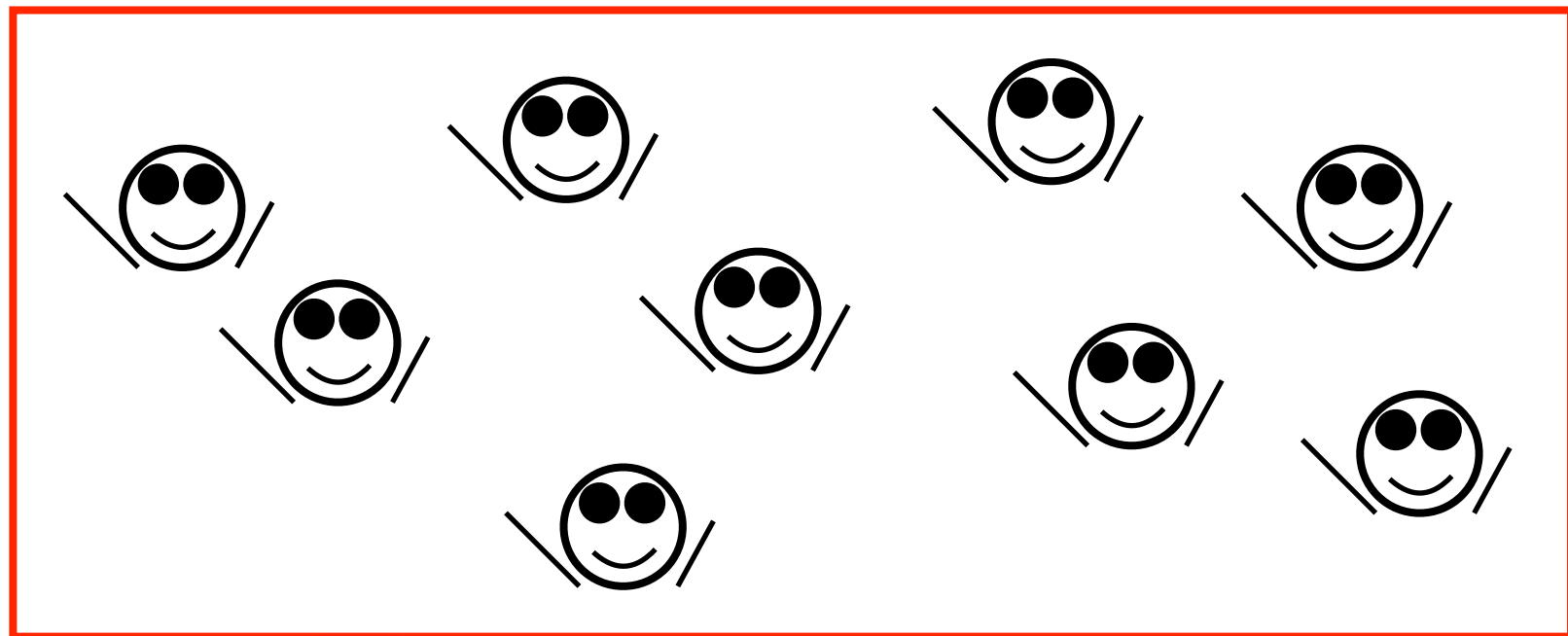


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## Does Coffee Improve Programming Ability?

Design I: before and after

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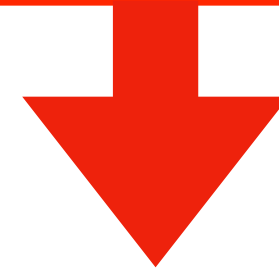
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for the project before  
(no coffee)

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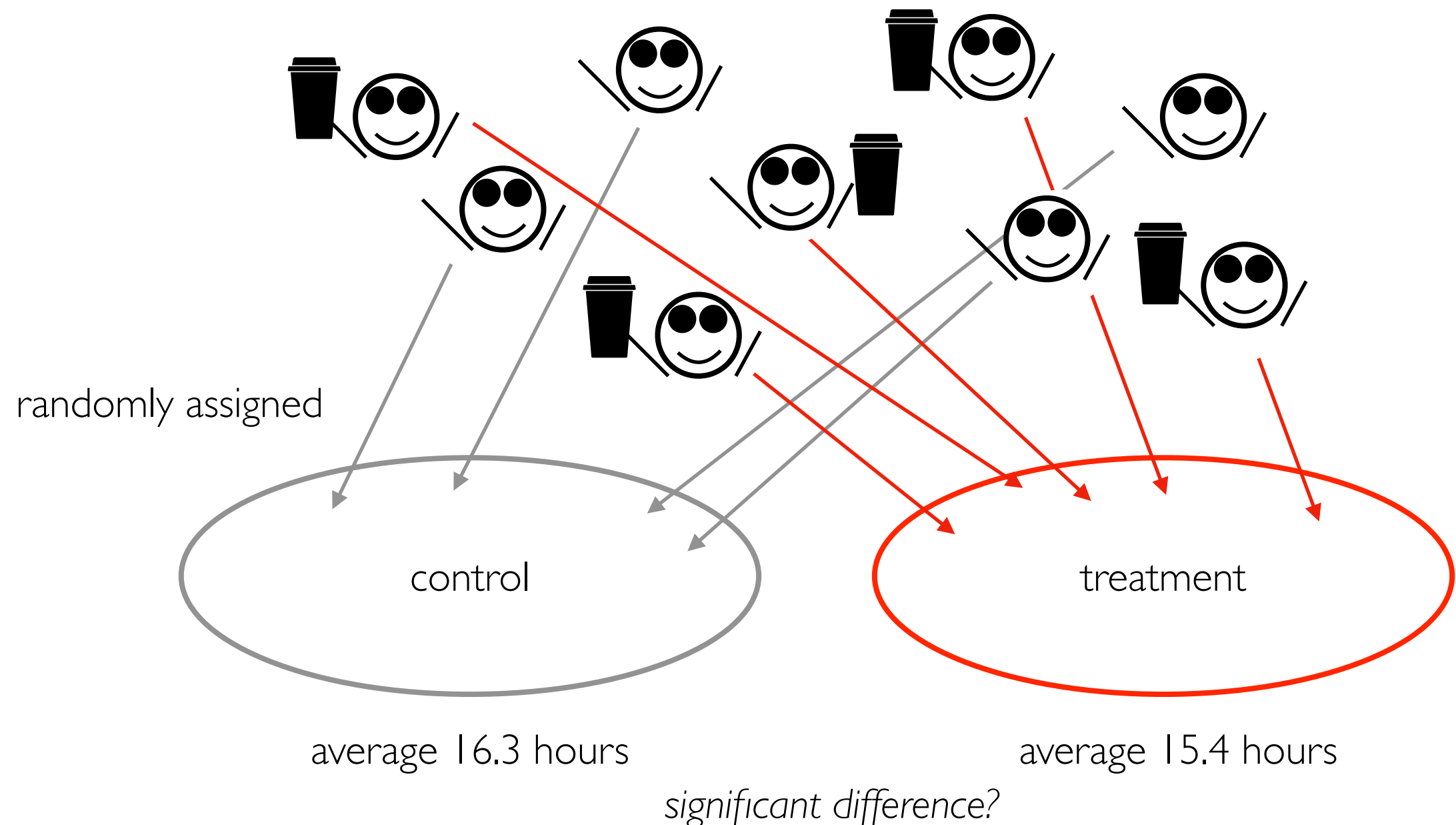
concerns???

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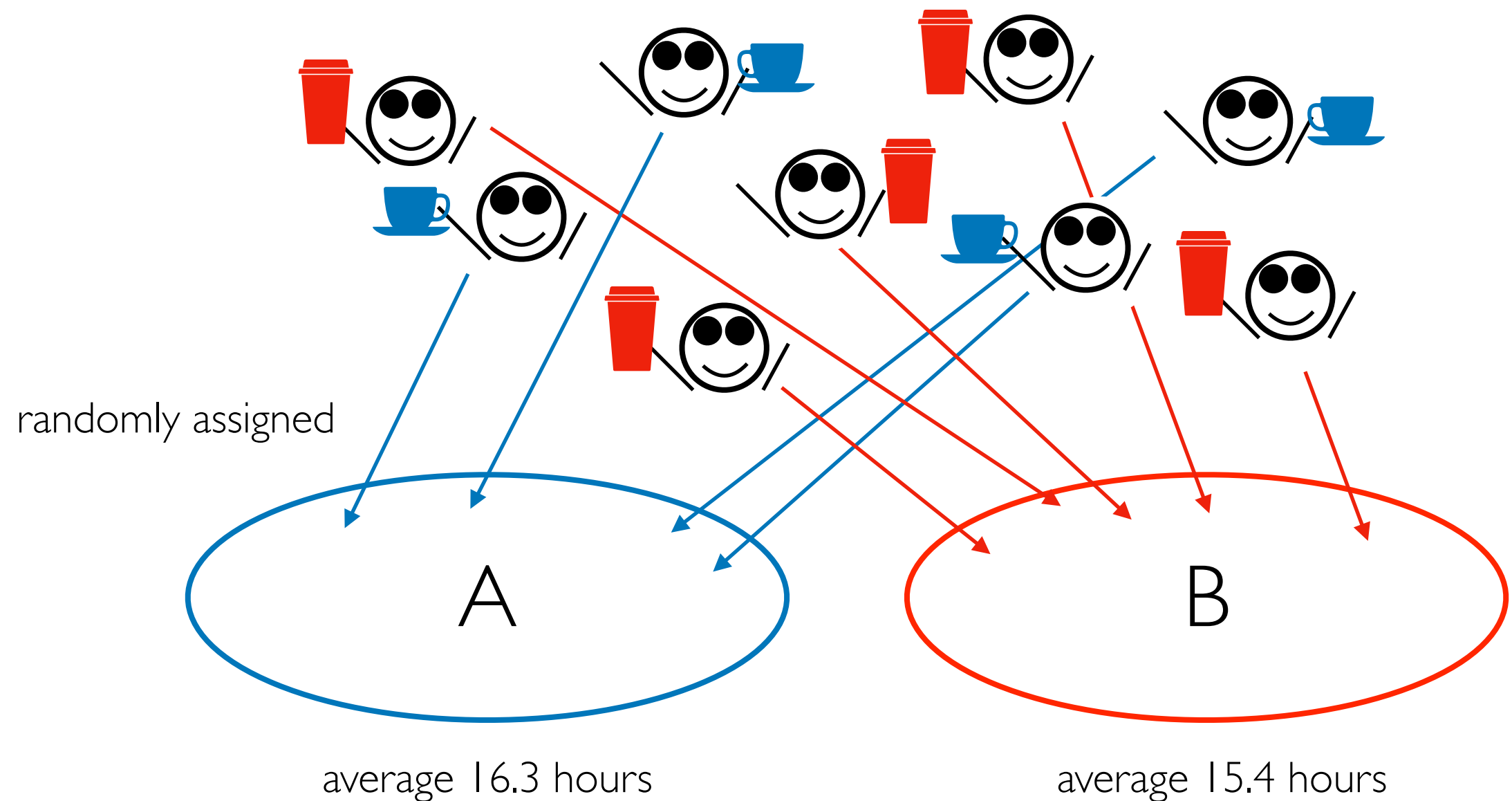
Design 2: randomly assigned control and treatment groups



# Experiment Design:

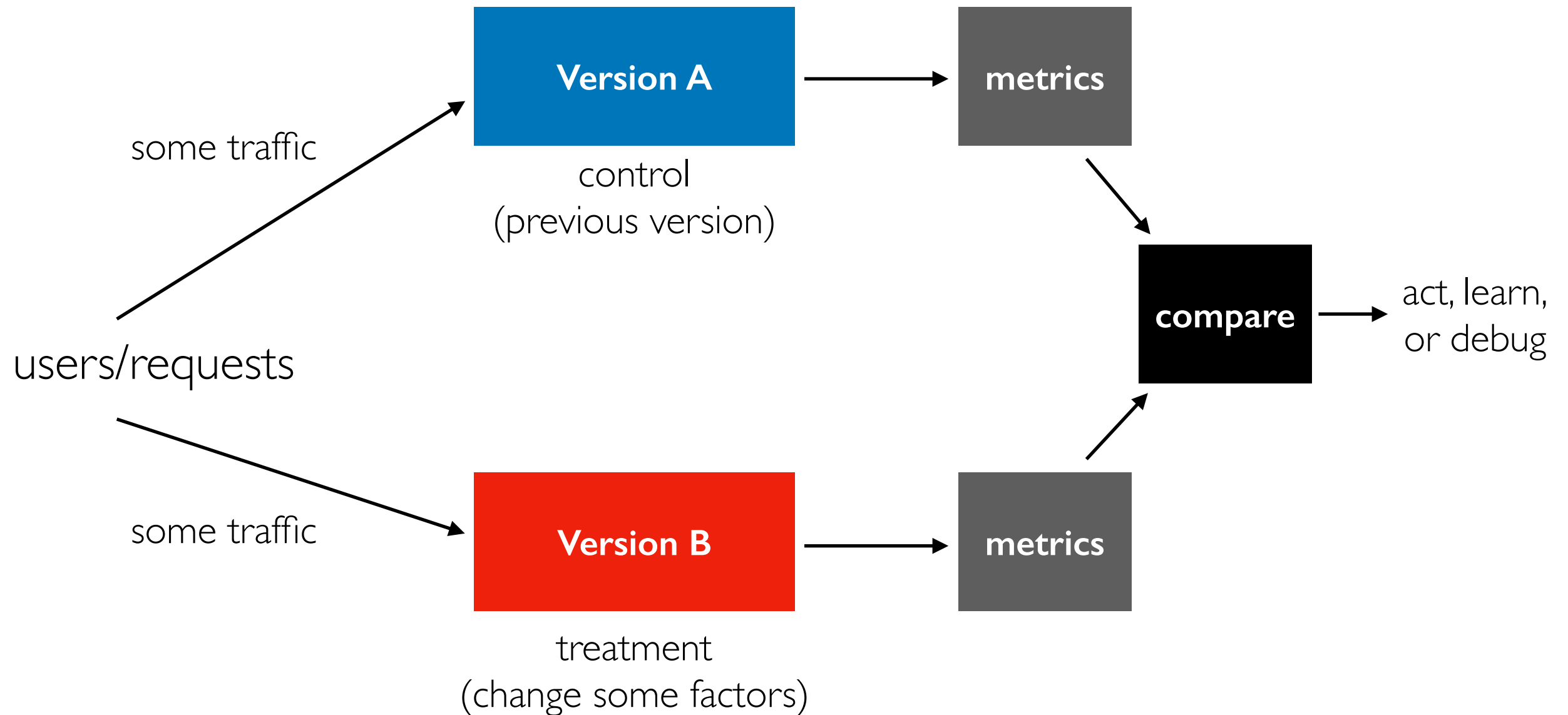
Is coffee or tea better for programming?

A/B Testing

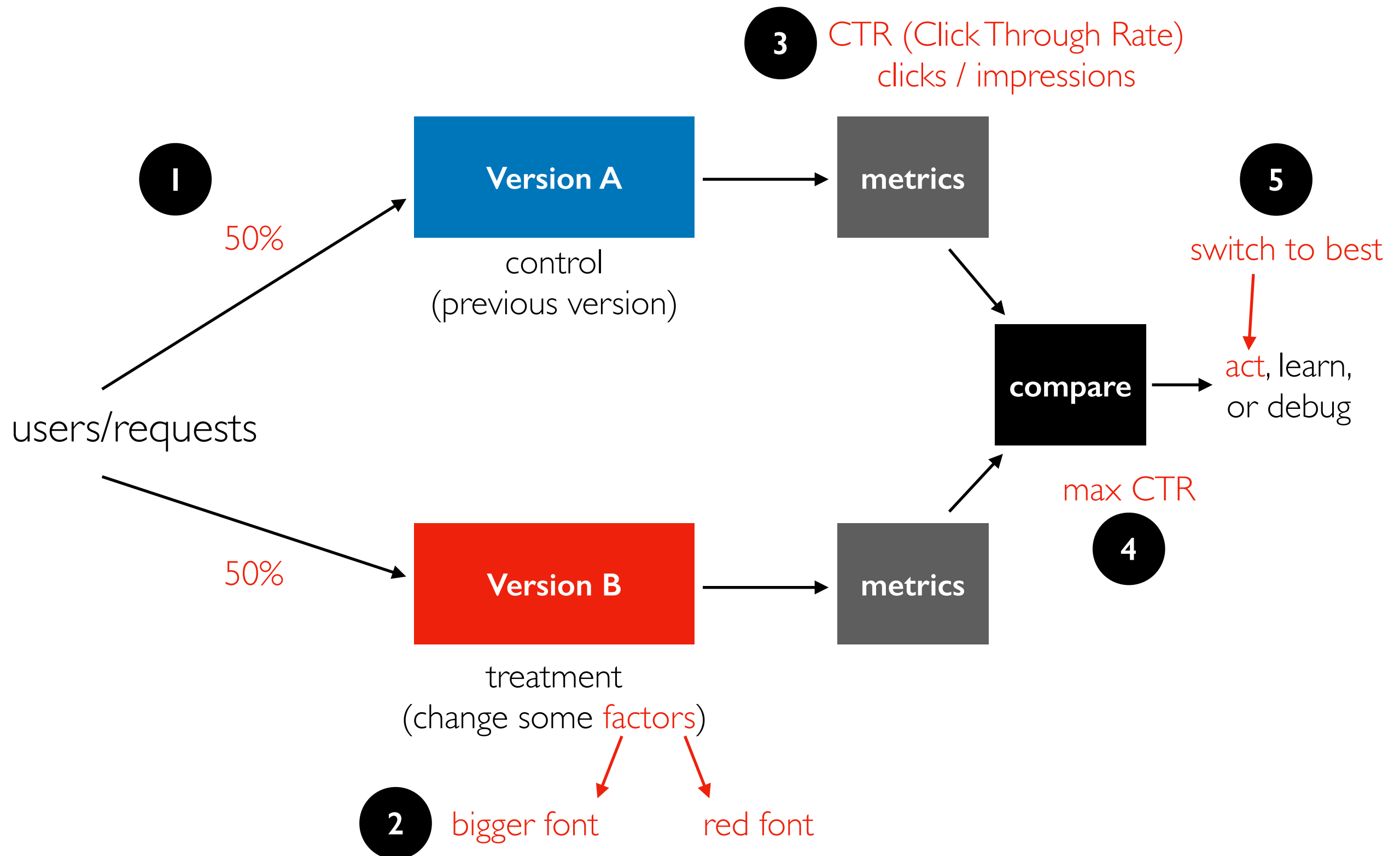




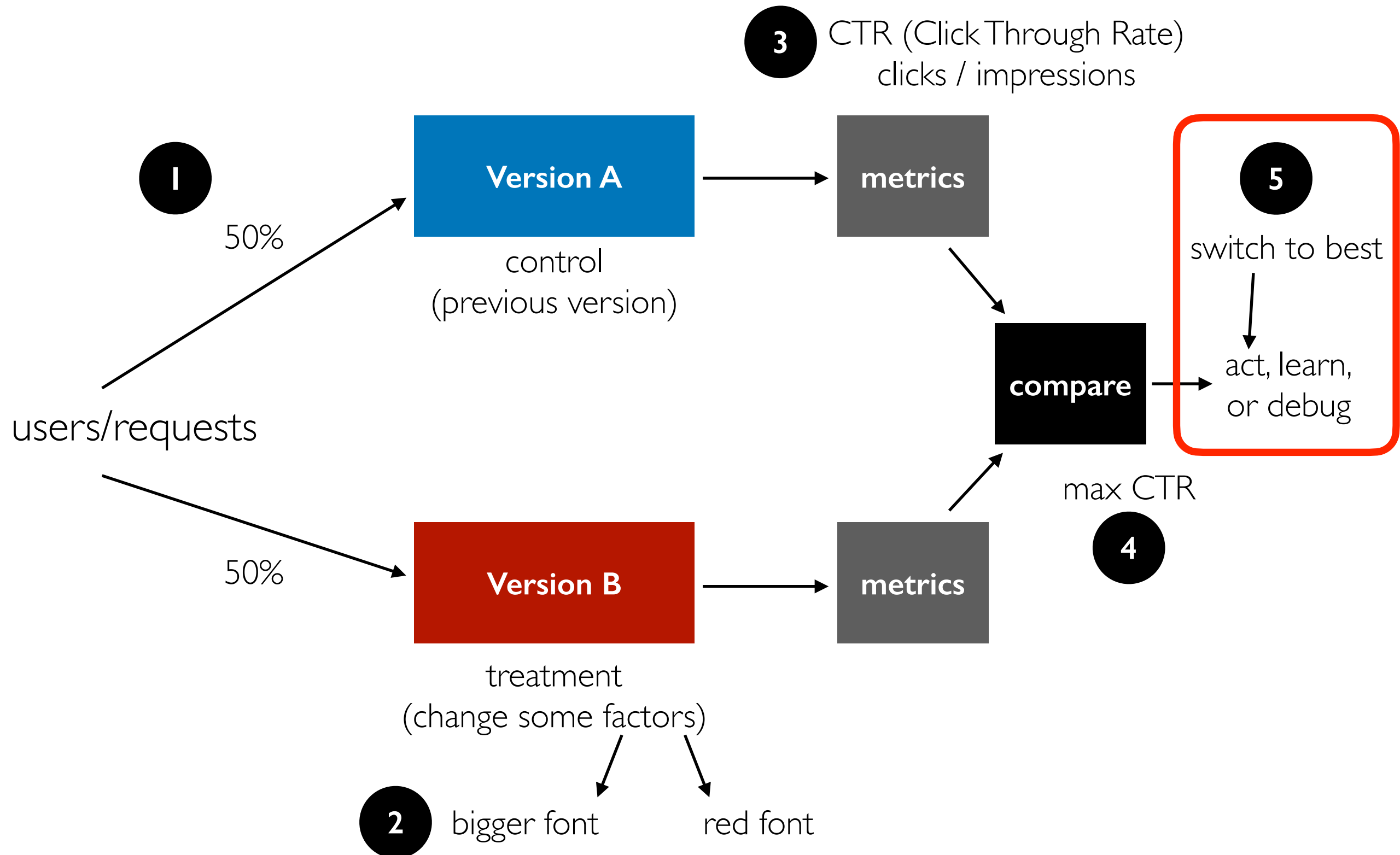
# A/B Test Overview (for web applications!)



# Example 1: Link to Donation Page

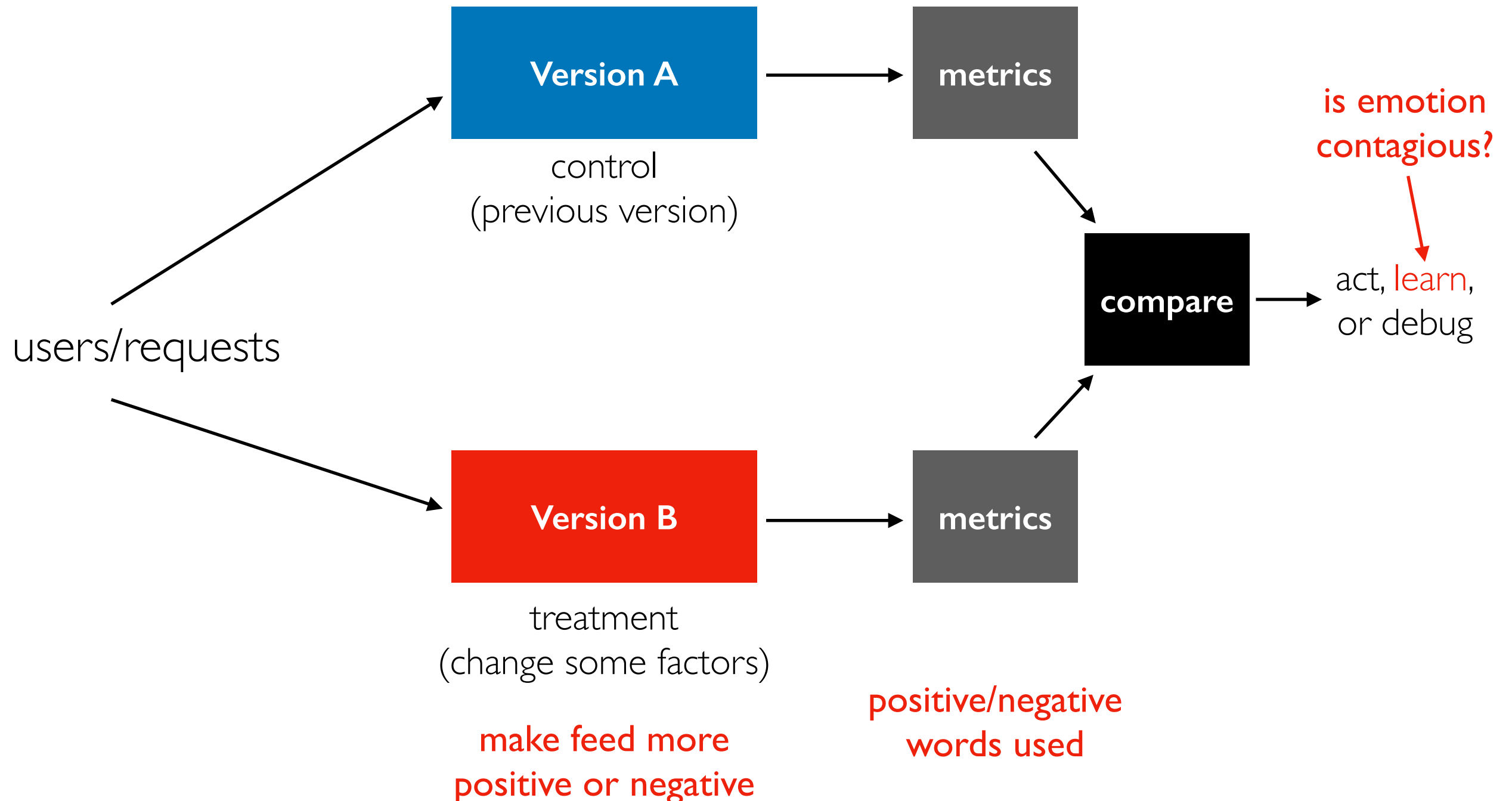


# Lecture Outline



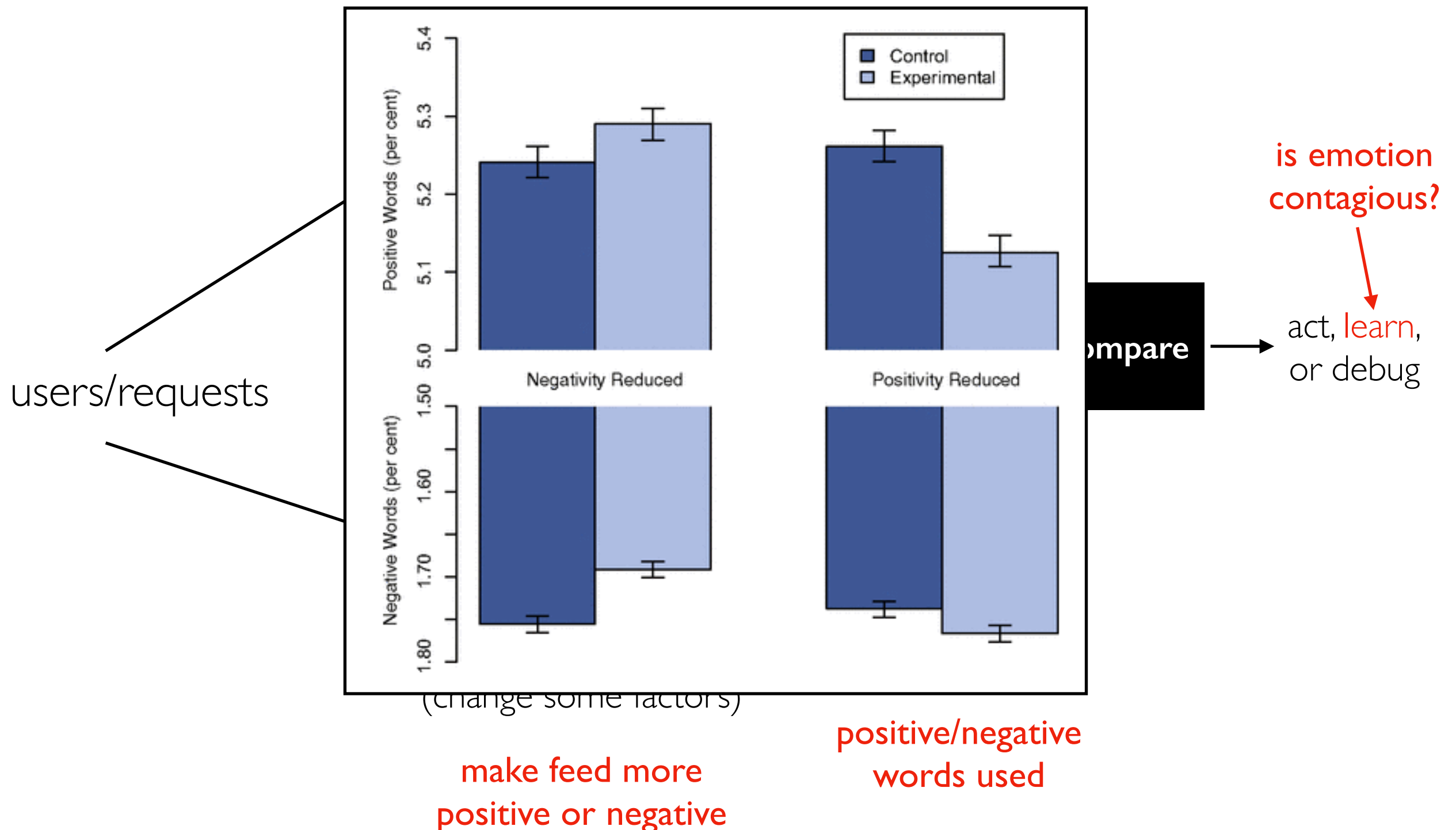
# Example 2: Facebook Emotional Contagion Study

Reading: <https://techcrunch.com/2014/06/29/ethics-in-a-data-driven-world/>



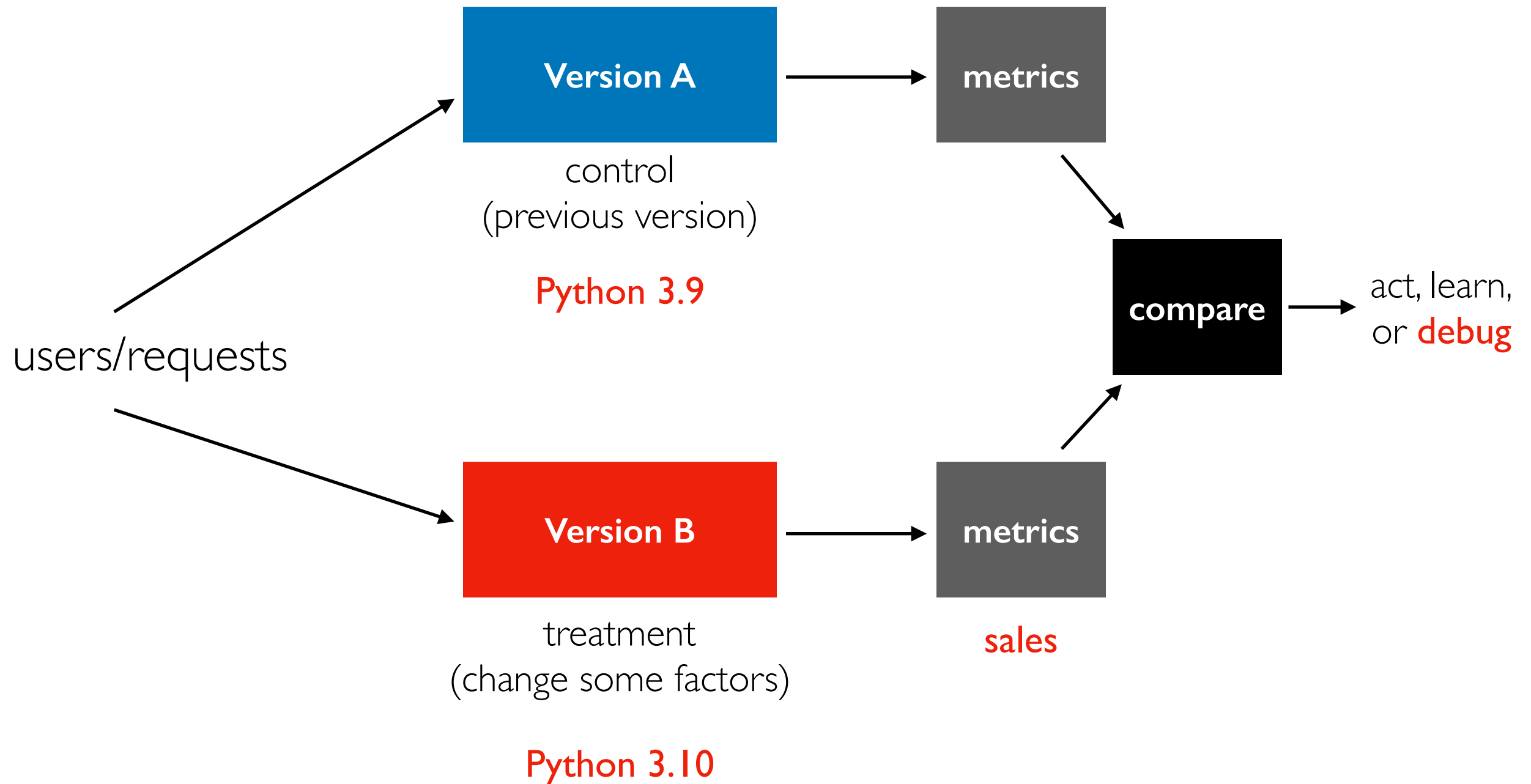
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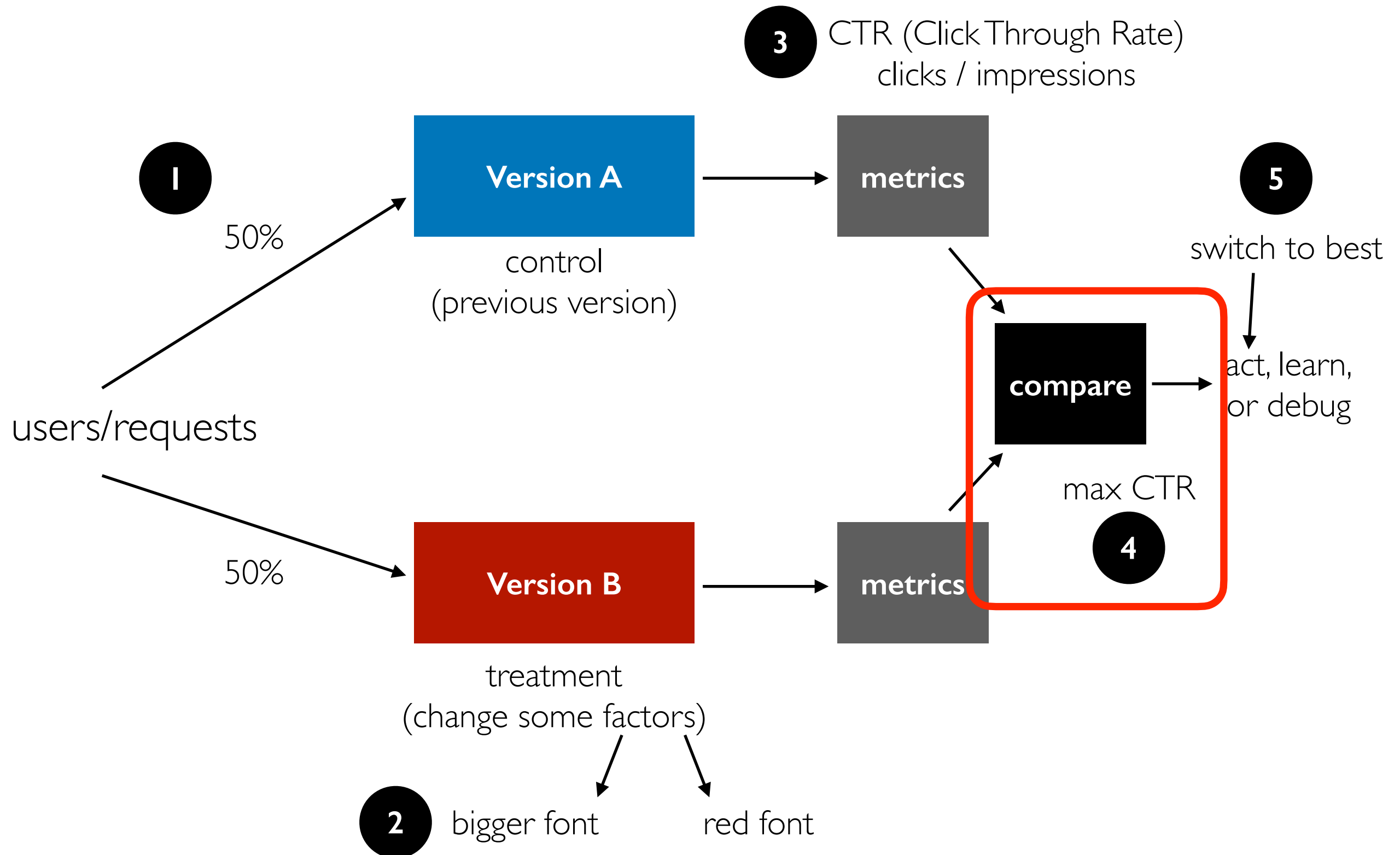


didn't need to submit to the IRB (Institutional Review Board) -- *when should it be required?*

# Example 3: Update Python Version



# Lecture Outline



# Comparisons

Example Metric: **CTR** (Click-Through Rate)

$\text{CTR} = \text{clicks} / \text{impressions}$

"Impression" means user saw it

	click	no-click
A	12	68
B	6	14

df: contingency table

how many B **impressions** were there?  
what was B's **CTR**?



# Comparisons

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how many B **impressions** were there? 20  
what was B's **CTR**?  $6/20 = 30\%$

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df: contingency table

```
1 df["click"] / (df["click"] + df["no-click"])
A    0.15
B    0.30
dtype: float64
```



is the improvement noise?

# Comparisons

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dtype: float64

df: contingency table

pip3 install scipy

```
1 import scipy.stats as stats
2 _, pvalue = stats.fisher_exact(df)
3 pvalue
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[https://docs.scipy.org/doc/scipy/reference/generated/scipy.stats.fisher\\_exact.html](https://docs.scipy.org/doc/scipy/reference/generated/scipy.stats.fisher_exact.html)

0.1886443478471497

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**p-value** is probability of seeing a difference this extreme (or more) if both ratios were generated by the same underlying process (the one most likely to generate this)

**"significant"** means p-value is less than some threshold (e.g., 5%)

**false positive** means it is significant even though underlying process is same

# Comparisons

*out of 200 neutral changes, how many will falsely show up as significant if we set our p-value threshold to 5%?*

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will falsely show up as significant if we  
set our  $p$ -value threshold to 5%?*

10

*occasionally run A/A tests to make  
sure the system is working (false  
positive rate should be as expected)*

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*df: contingency table*

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3 outcomes, based on CTRs and significance

- A is significantly better
- B is significantly better
- *neither wins*

what to do?

- ideas???



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**3 outcomes, based on CTRs and significance**

- A is significantly better
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**what to do?**

- collect more data
- ignore significance, just look at CTR  
(indecision may be the worst decision)
- choose previous version A (probably fewer bugs)
- choose new version B (for simplicity or other merits)

# Which Version Has Higher Whole-page CTR?

Version A

Version A search results for 'amazon' show a clean layout with a search bar at the top. Below the search bar are tabs for ALL, SHOPPING, IMAGES, VIDEOS, MAPS, and NEWS. The results section shows 196,000,000 Results and a filter for Any time. The first result is 'Amazon.com - Amazon.com® Official Site' with a URL and a description. Below this are four promotional links: 'Shop Echo & Alexa Devices', 'Amazon Prime Benefits', 'Learn More About Alexa', and 'Shop Amazon Fire Tablets'. Further down is 'Meet the Fire TV Family' and a link to 'See results only from amazon.com'. The second result is 'Amazon.com: Online Shopping for Electronics, Apparel ...' with a URL, a description, a rating of 5/5 stars, and a price of \$21.06. Below this are links for 'Sign In' and 'Books', and a 'See more' link at the bottom.

amazon

ALL SHOPPING IMAGES VIDEOS MAPS NEWS

196,000,000 Results Any time ▾

[Amazon.com - Amazon.com® Official Site](#)  
<https://www.amazon.com> ▾  
(Ad) Earth's biggest selection of books, electronics, apparel & more at low prices.  
amazon.com has been visited by 1M+ users in the past month  
Fast Shipping · Explore Amazon Devices · Shop Prime Wardrobe · Try Prime for Free

[Shop Echo & Alexa Devices](#)  
Play music, get news, control your smart home & more using your voice.

[Amazon Prime Benefits](#)  
Fast free delivery, streaming video, music, photo storage & more.

[Learn More About Alexa](#)  
Hands-free voice control for music, calling, smart home devices & more.

[Shop Amazon Fire Tablets](#)  
Tablets designed for entertainment at an affordable price. Learn more.

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[Amazon.com: Online Shopping for Electronics, Apparel ...](#)  
<https://www.amazon.com> ▾  
Free One-Day Delivery on millions of items with Prime. Low prices across earth's biggest selection of books, music, DVDs, electronics, computers, software, apparel & accessories, shoes, jewelry, tools & hardware, housewares, furniture, sporting goods, beauty & ...  
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[Sign In](#)  
This site won't let us show the description for ...  
[How to Use Account Switching](#)

[Books](#)  
Books at Amazon. The Amazon.com Books homepage helps you explore Earth's Biggest ...

[See more](#) ▾

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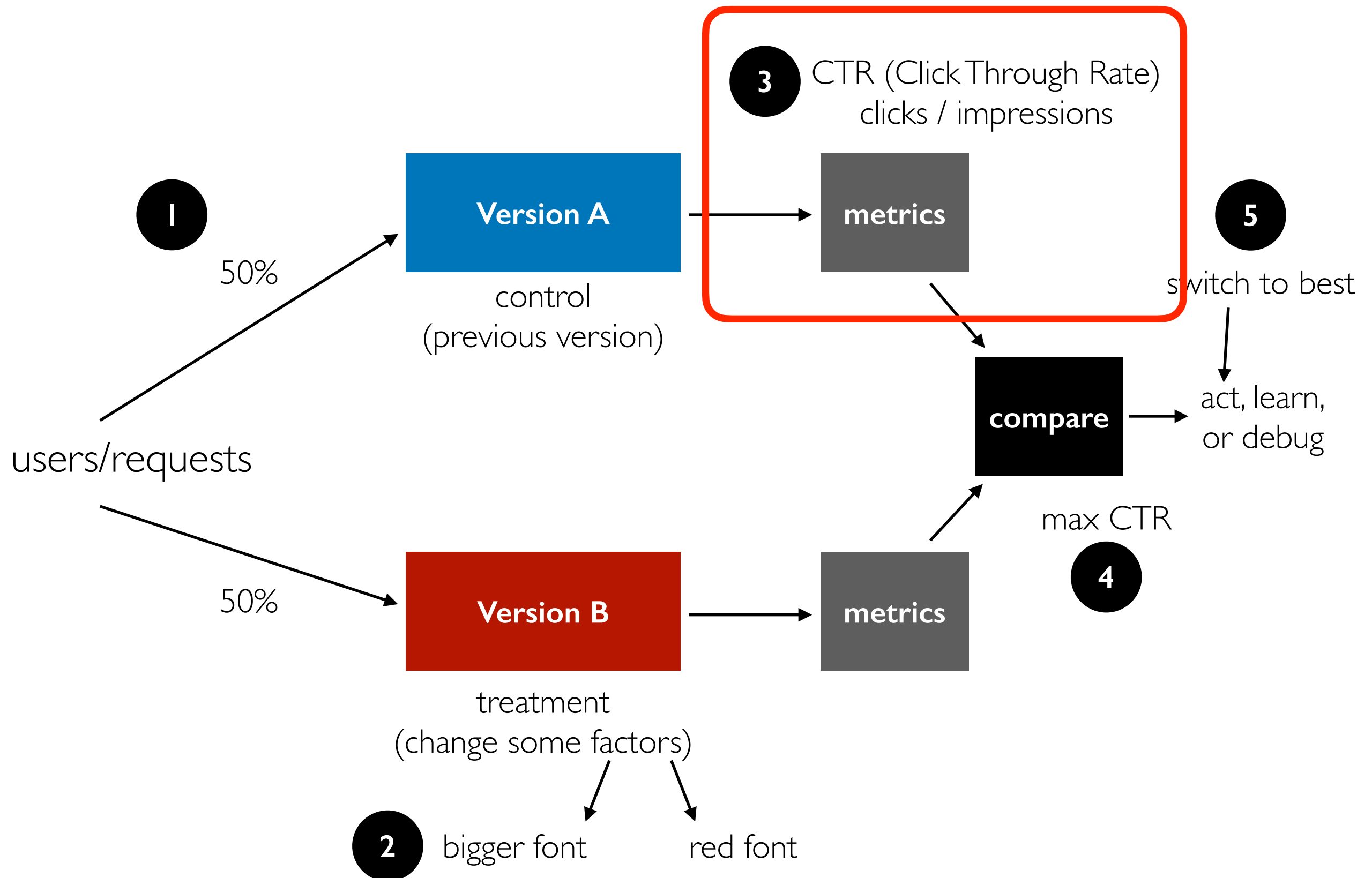
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Version B

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**Lesson:** metrics should inform humans, not directly determine decisions

# Lecture Outline



# Metrics

Things to measure:

- clicks -- when are they bad?

# Metrics

## Things to measure:

- clicks
- scroll (did they read it?)
- subscribe/unsubscribe
- other ideas?

# Metrics

## Things to measure:

- clicks
- scroll (did they read it?)
- subscribe/unsubscribe
- purchases/returns
- hover (did they think about it?)
- shares
- likes/upvotes
- comments

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**combos:** Bing measures how often people click a result link and don't hit back within 30 seconds



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what is the effect of B?

B is **send twice as many spammy emails**

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B is **remove price from product page link**

what is the effect of B?

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**combos:** Bing measures how often people click a result link and don't hit back within 30 seconds

what is the effect of B?

B is **remove price from product page link**

**Lesson:** it's easy to shift clicks

what is the effect of B?

B is **send twice as many spammy emails**

**Lesson:** it's hard to measure long-term effects (noisy!), so use common sense

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Decide beforehand on one **OEC** metric: Overall Experiment Criterion

- Bing has thousands of debug metrics, but only 4 OECs.

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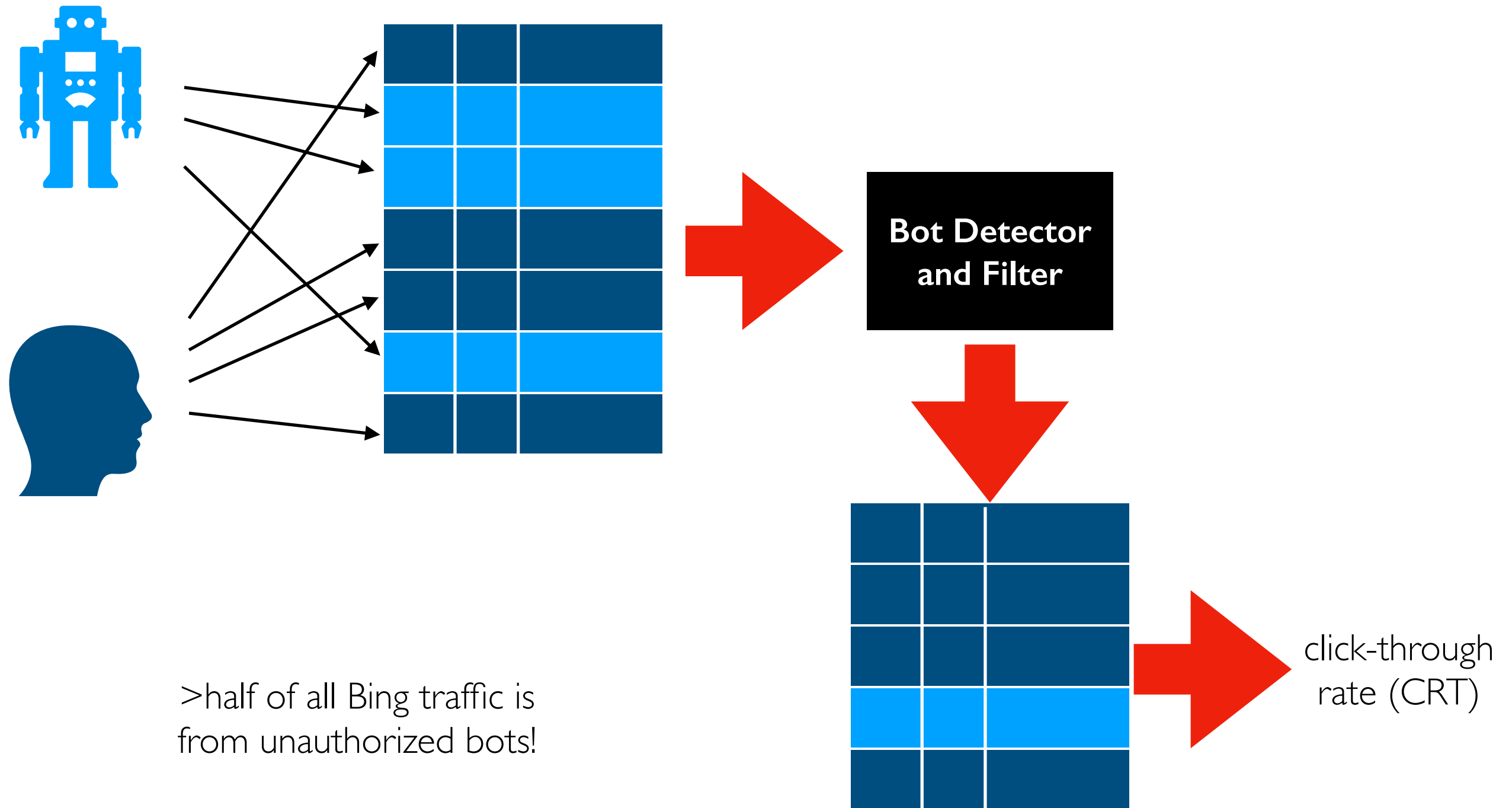
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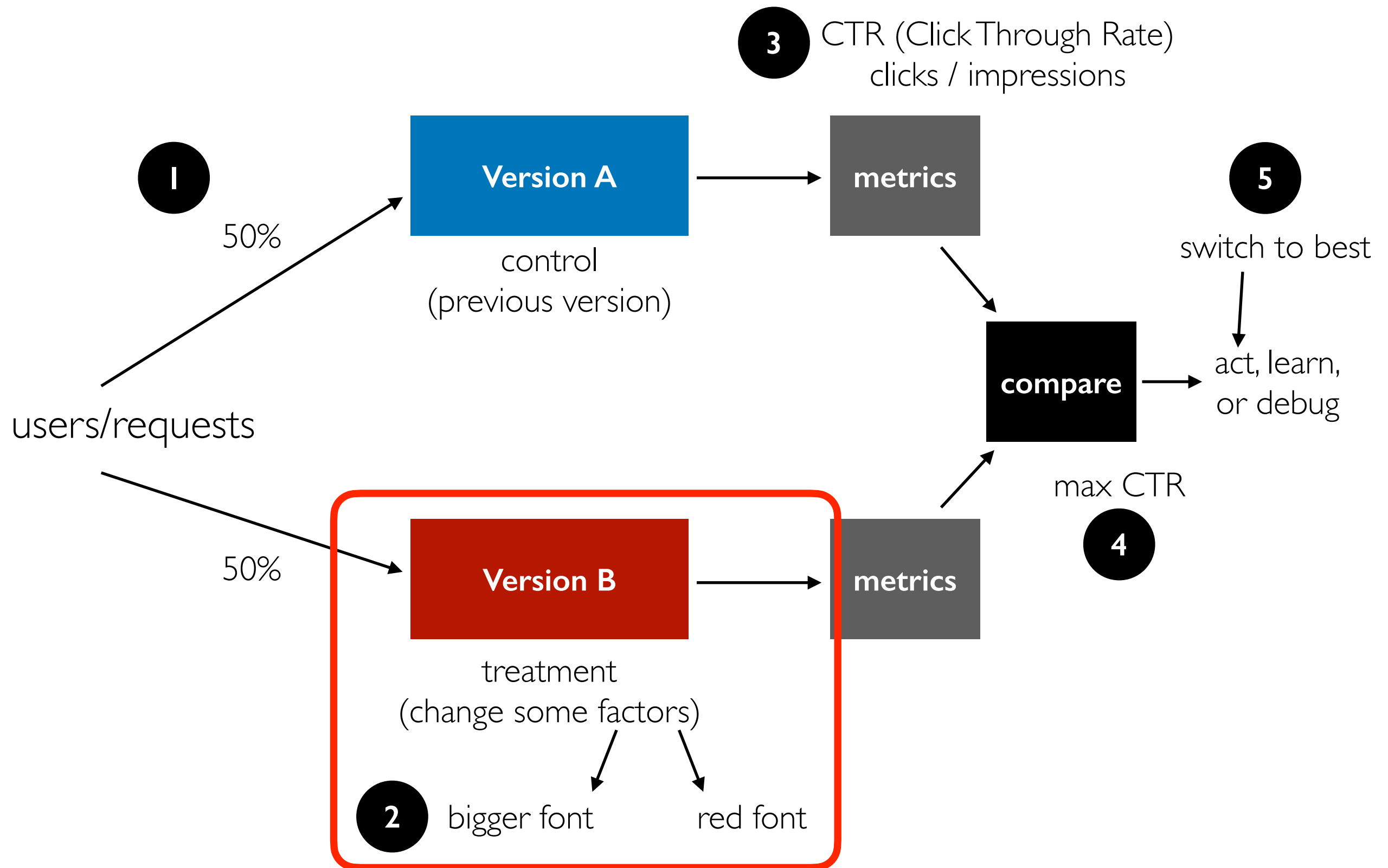
## Decide beforehand on one **OEC** metric: Overall Experiment Criterion

- Bing has thousands of debug metrics, but only 4 OECs. Try to consider cost as well as benefit!
- As a rule of thumb, *"if you make something bigger, more people will click on it"* ~ Ron Kovani
- Making part of the site better could hurt other parts if you have a naive OEC

# Metrics Should be on Uniformly Cleaned Data



# Lecture Outline



# Treatment

Run two variants side by side: control (A) and treatment (B)

Treatment consists of **one or more factors** changed:

- wording
- slowdown
- changes "invisible" to user (e.g., software updates)
- **what else?**



# Treatment

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Treatment consists of **one or more factors** changed:

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- changes "invisible" to user (e.g., software updates)
- time of day (for emails sent)
- font, size, color, icons, graphic design in general
- recommendation algorithm used
- sequence of steps necessary to make a purchase
- database that is faster for some queries (and slower for others)

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**Lesson:** don't be too attached to your work, be redundant and ready to throw things away

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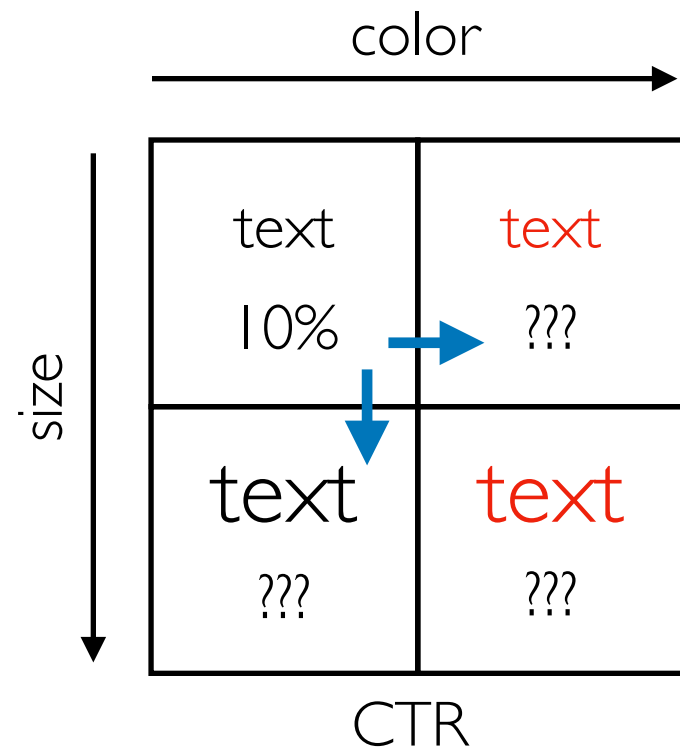
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**Lesson:** don't be too attached to your work, be redundant and ready to throw things away

there's also plenty of low-hanging fruit!

"stop debating, it's easier to get the data" ~ Ron Kohavi

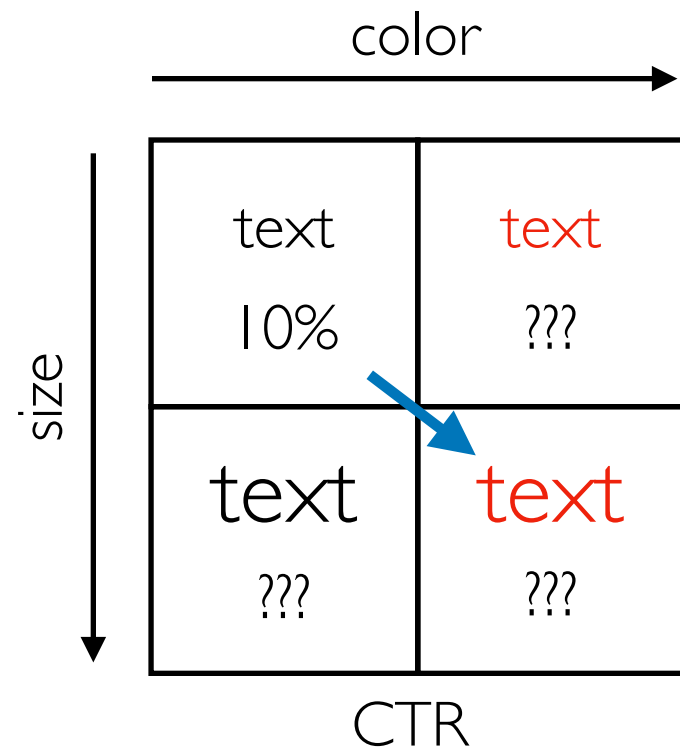
# Finding the Best Combination



Option I: OFAT (one factor at a time)

**Hypothesis:** large red  
font will be better

# Finding the Best Combination

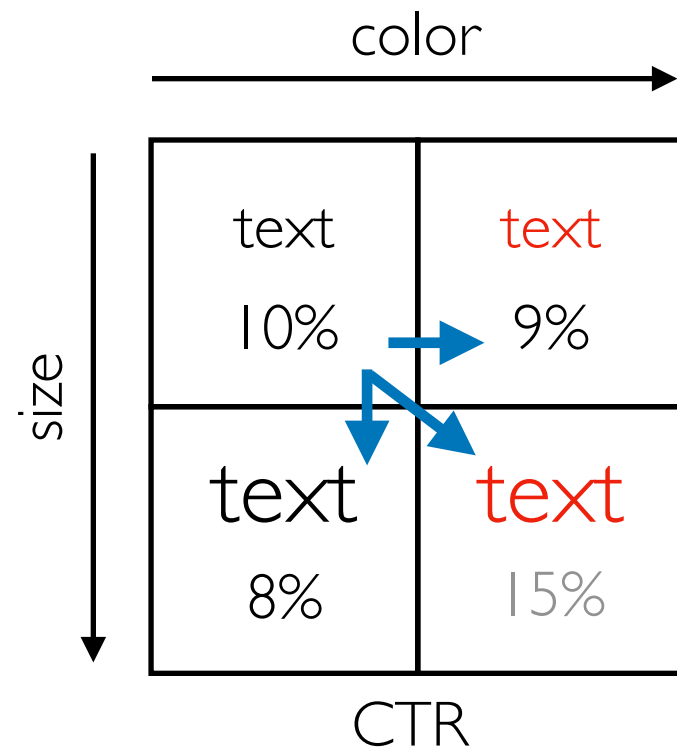


Option 1: OFAT (one factor at a time)

Option 2: introduce two factors at once

**Hypothesis:** large red font will be better

# Finding the Best Combination



**Hypothesis:** large red font will be better

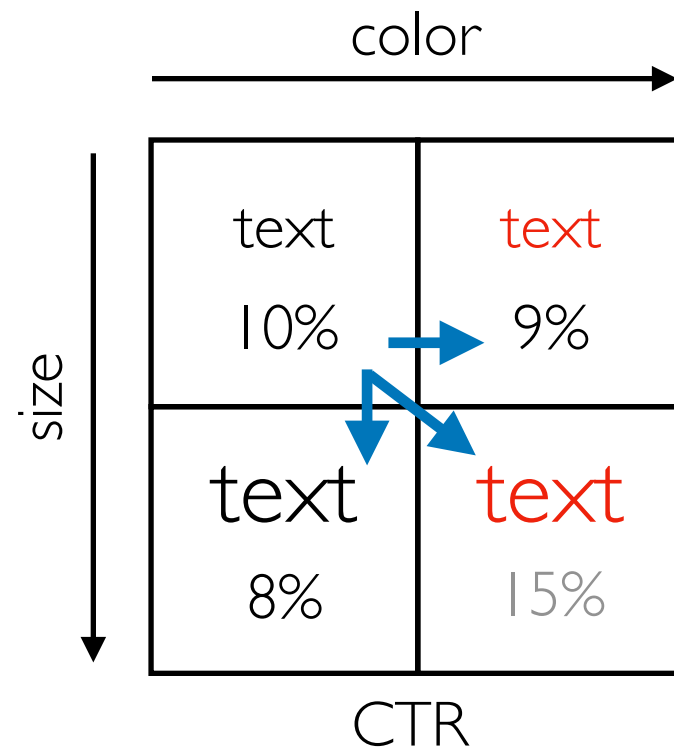
Option 1: OFAT (one factor at a time)

can usually learn more, but will never exploit factor interactions

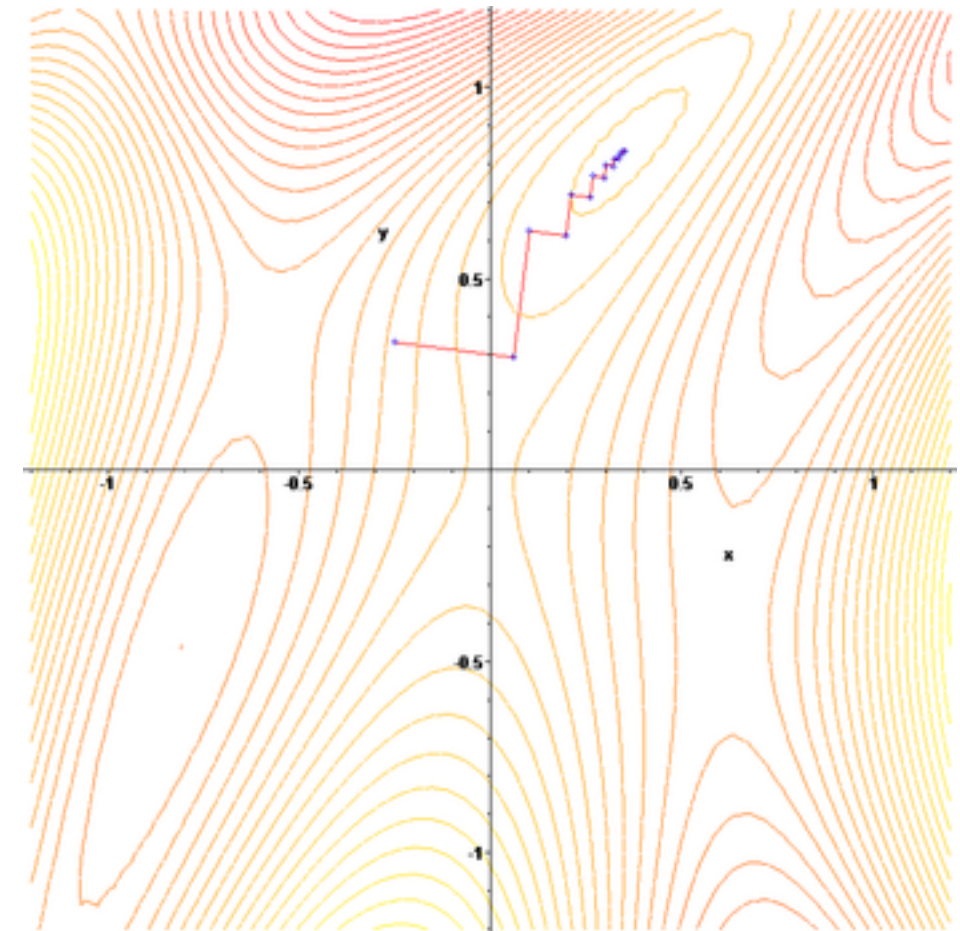
Option 2: introduce two factors at once

can choose a good design, but didn't learn what factors are important

# Finding the Best Combination



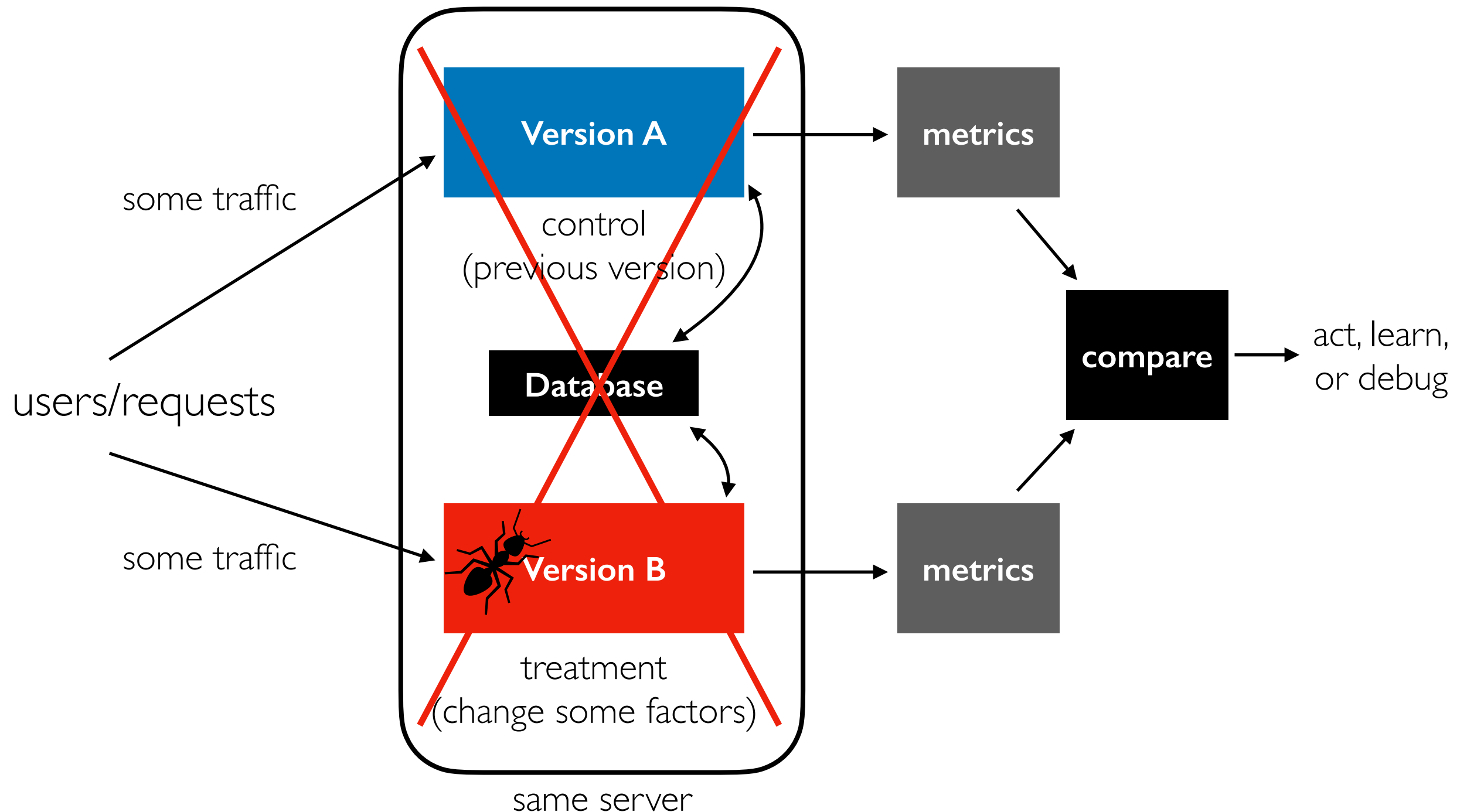
**Hypothesis:** large red font will be better



[https://en.wikipedia.org/wiki/Gradient\\_descent](https://en.wikipedia.org/wiki/Gradient_descent)

**Hill climbing:** imagine you're trying to find a peak (representing higher CTR). Taking small steps in the steepest direction is usually best, but not if you reach a local peak/optimum

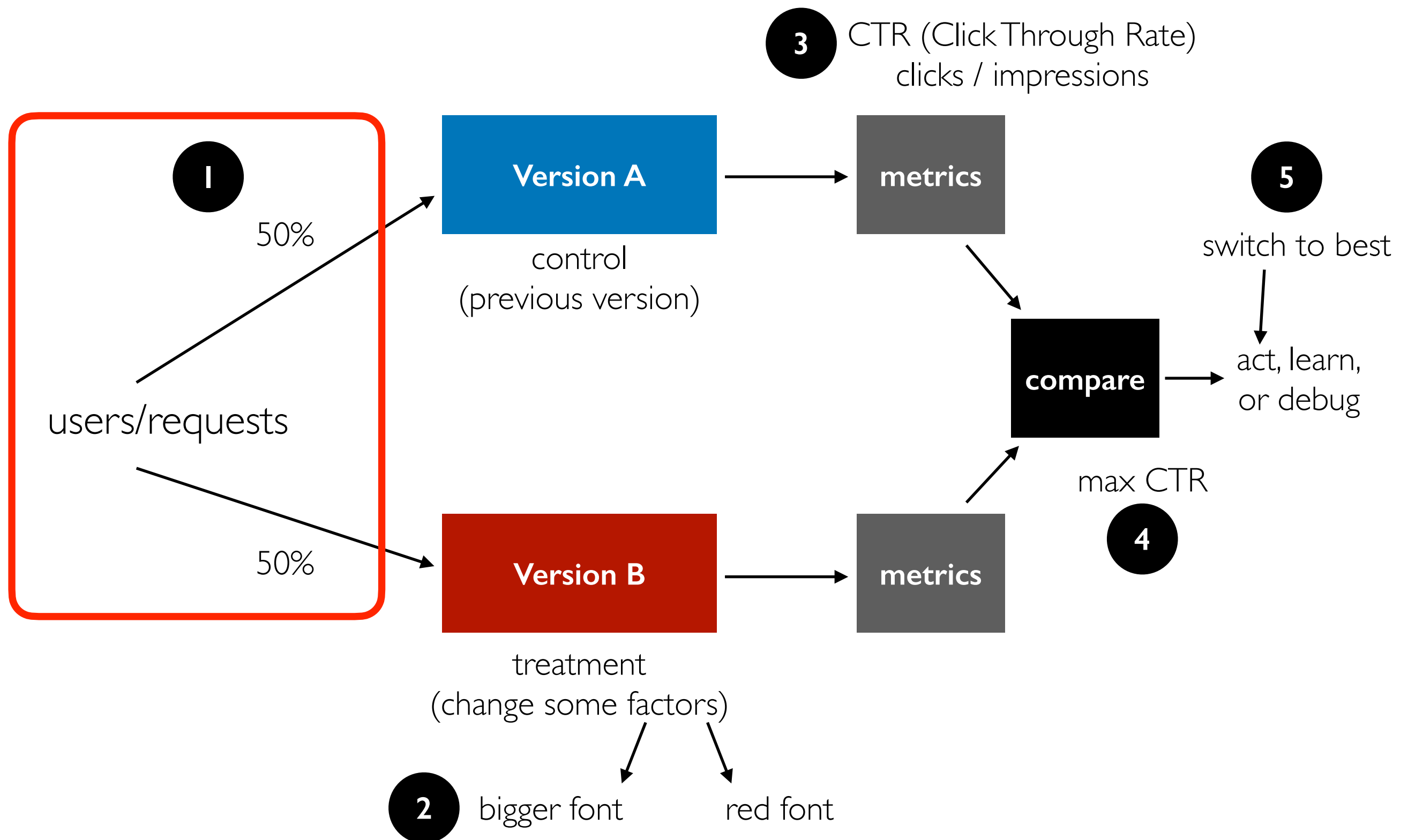
# Control/Treatment Disruptions



Different variants may save databases/servers, affecting performance of both. Bugs crashing the server will be especially bad! Metrics won't show the true blame.

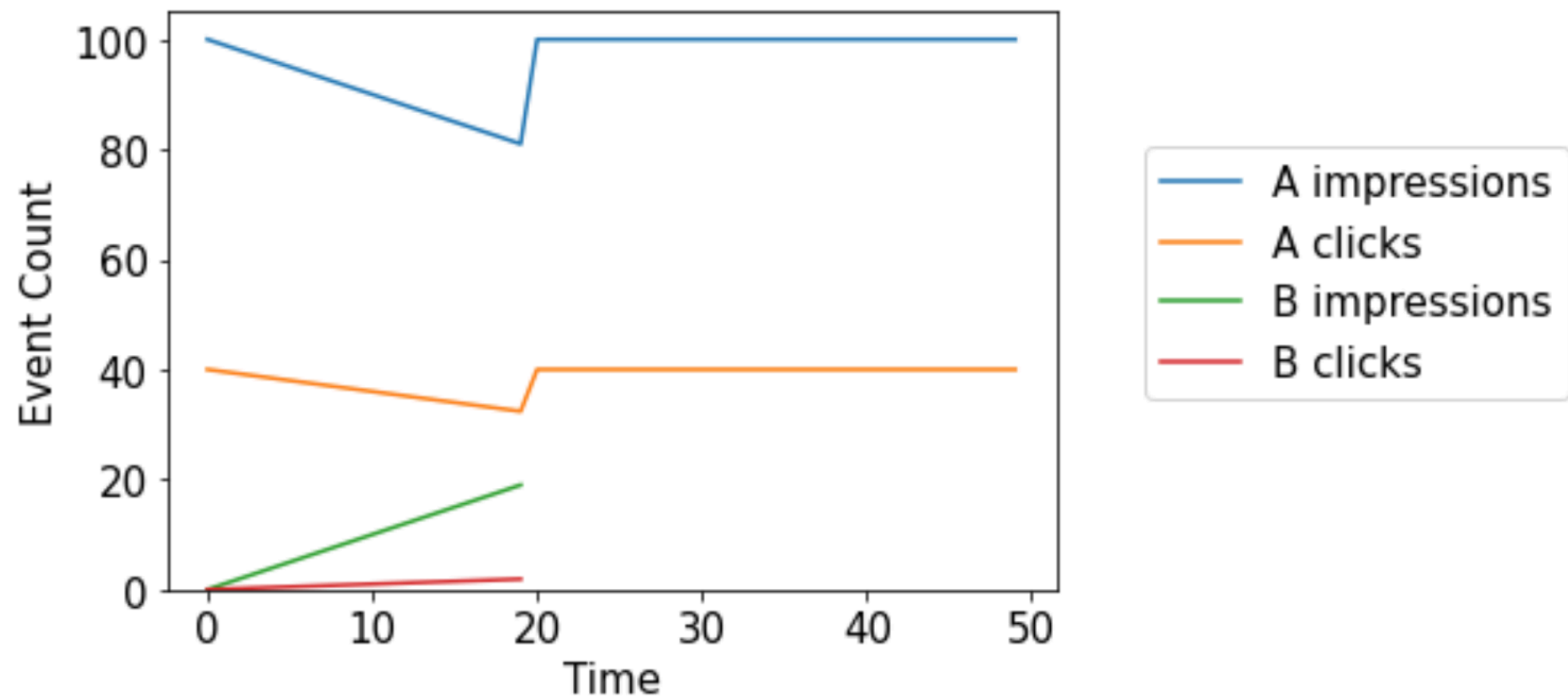


# Lecture Outline

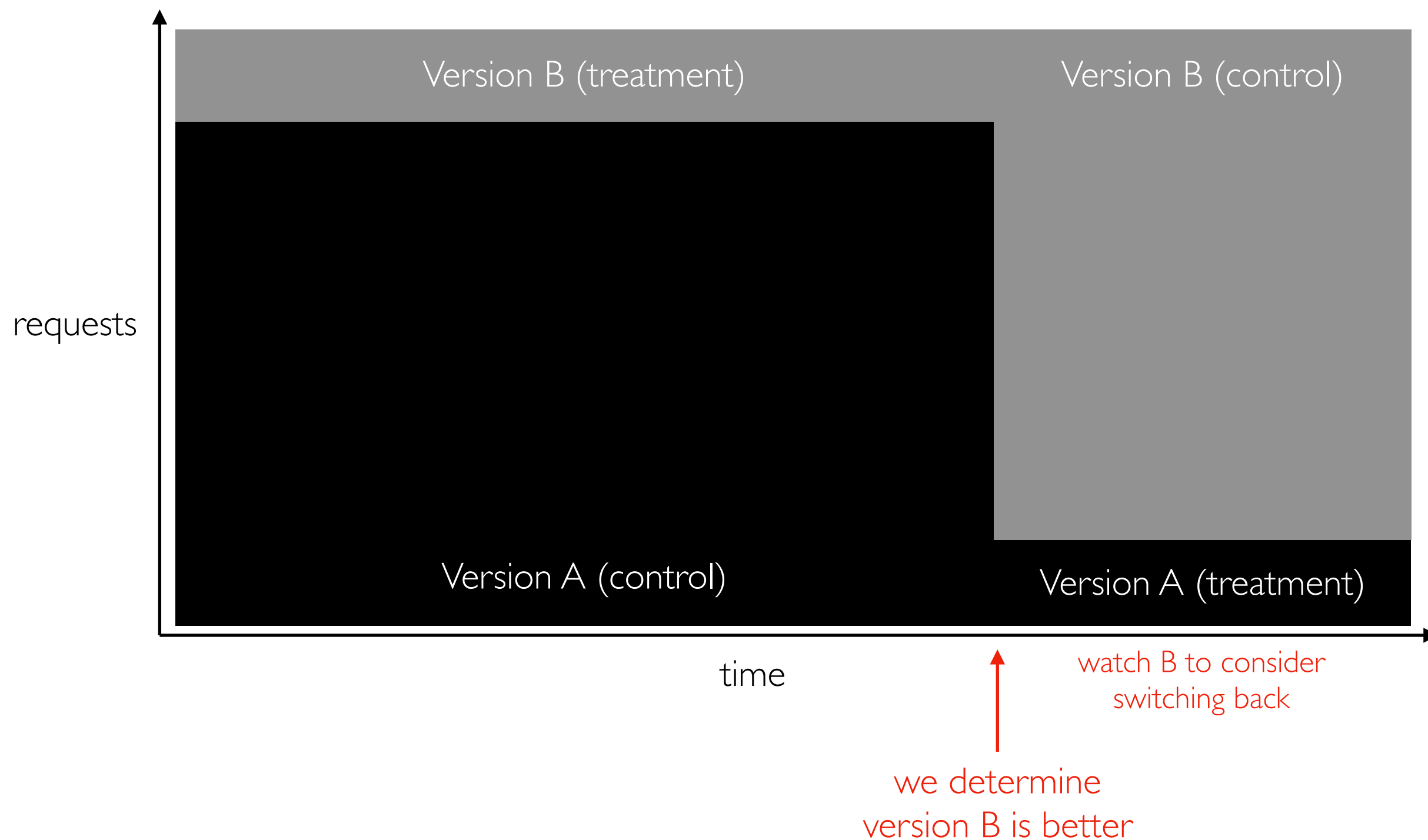


# What to split

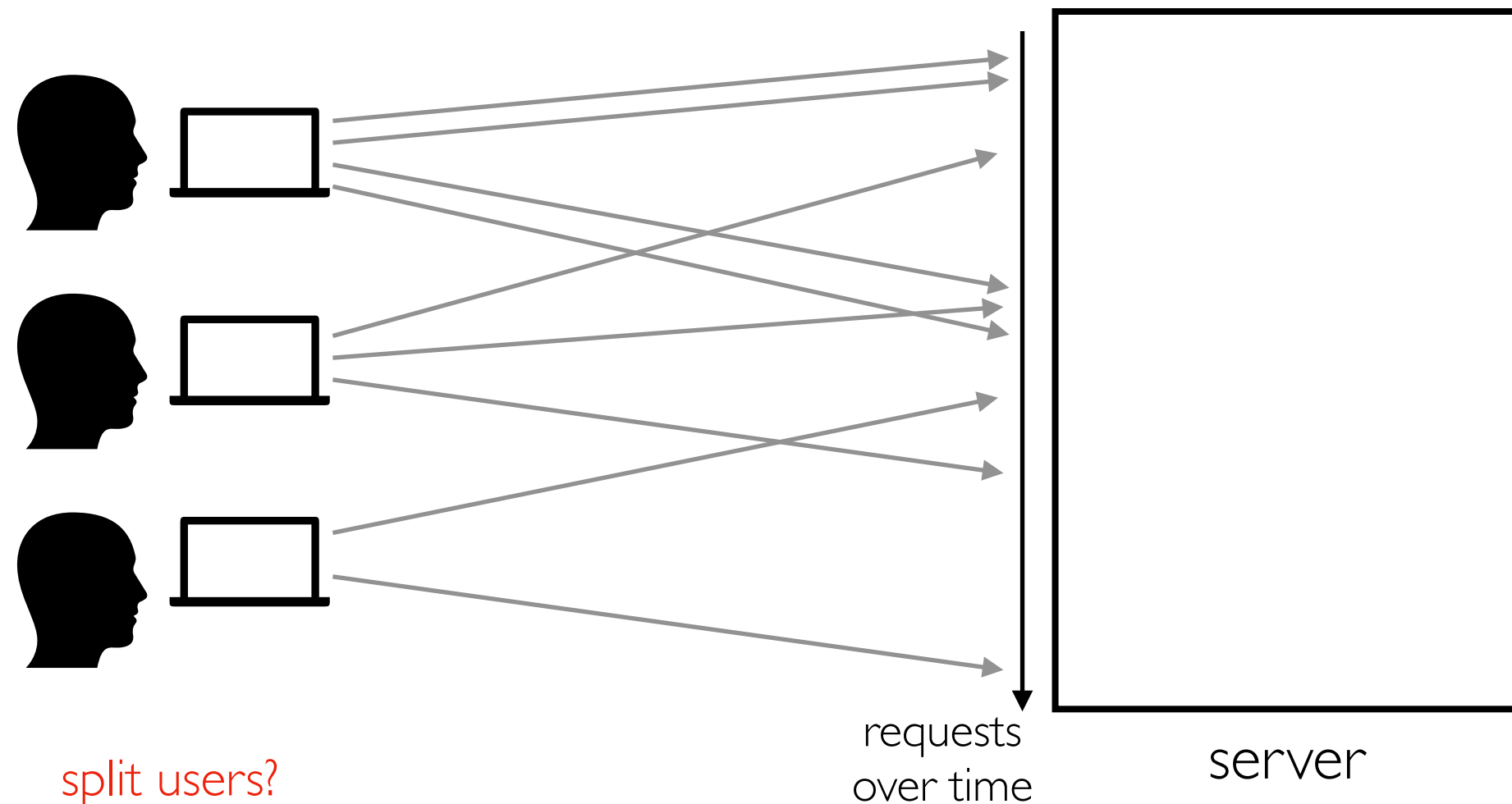
Don't go straight to 50/50!



# What if the real factor is **novelty**?



# What to split between control+reatment?



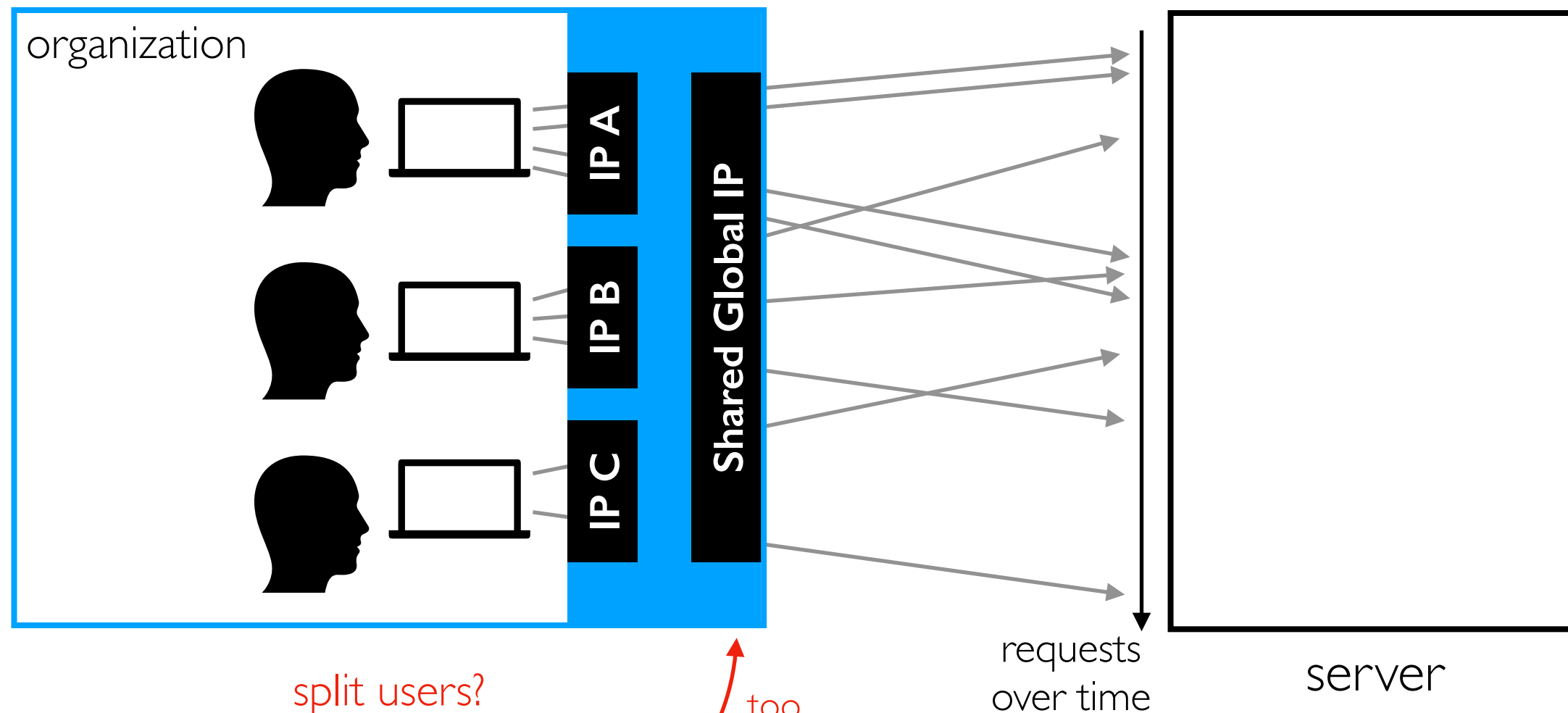
## how to identify?

- IP addresses
- signed-in services
- cookies

## or requests?

easier, but can't test over-time metrics or provide consistent experience

# What to split between control+reatment?



split users?

how to identify?

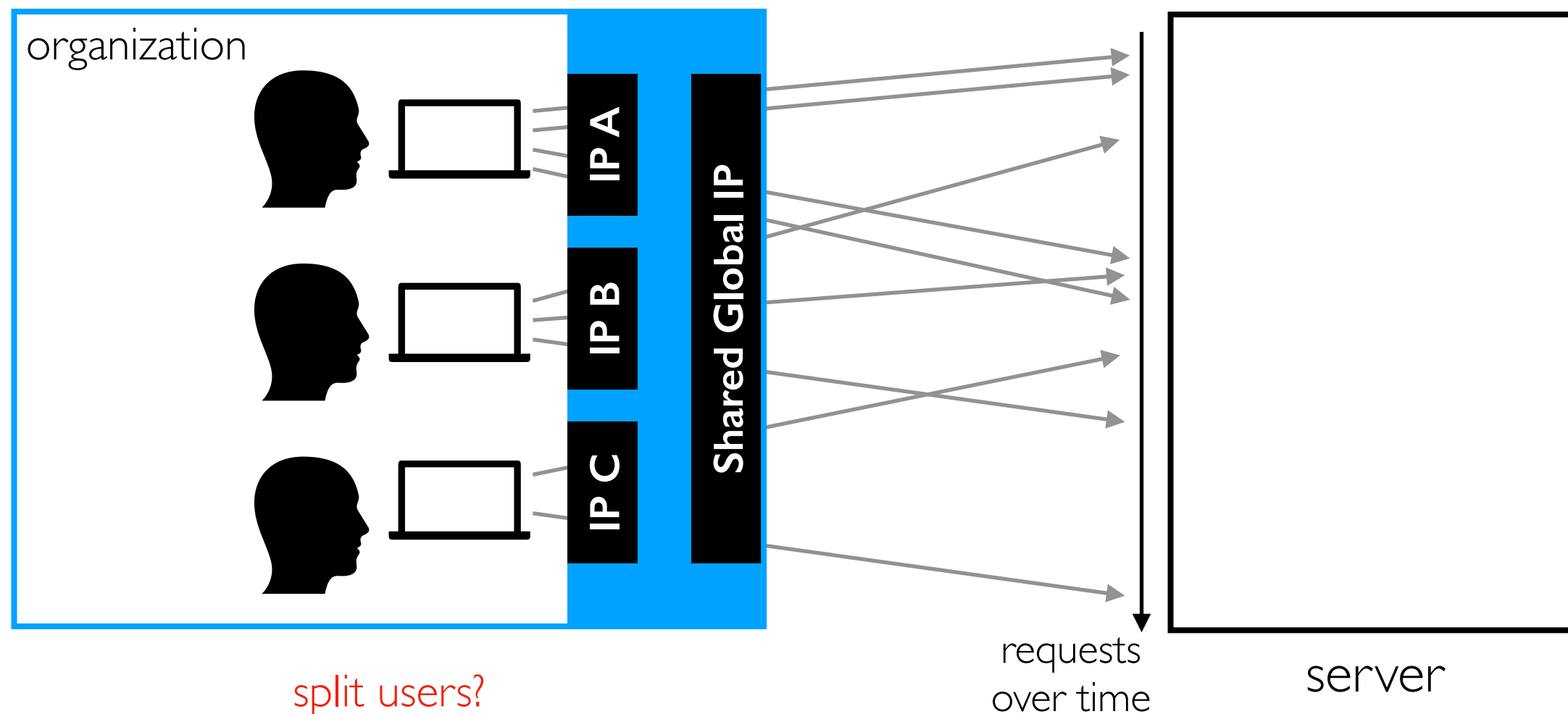
- IP addresses
- signed-in services
- cookies

too  
many  
share

or requests?

easier, but can't test over-  
time metrics or provide  
consistent experience

# What to split between control+reatment?



split users?

how to identify?

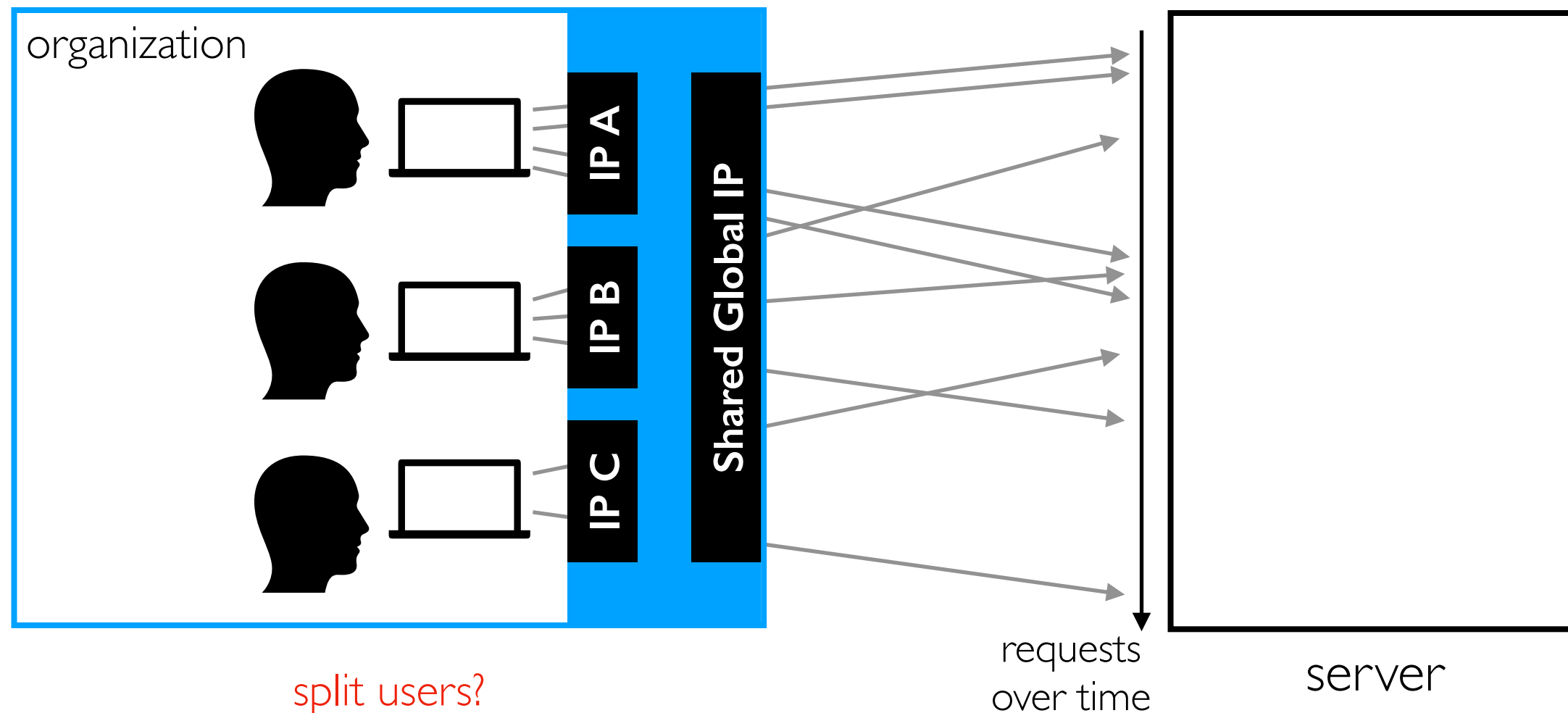
- IP addresses
- signed-in services
- cookies

or requests?

easier, but can't test over-time metrics or provide consistent experience

ideal for when applicable

# What to split between control+reatment?



how to identify?

- IP addresses
- signed-in services
- cookies



or requests?

easier, but can't test over-time metrics or provide consistent experience

# Cookies

**Cookies** are info that sites ask browsers to store locally and upload later.

```
from flask import request, Response, Flask

app = Flask(__name__)

@app.route('/')
def index():
    print(request.cookies)
    user_id = request.cookies.get("user", None)
    if user_id == None:
        user_id = new_id()
    resp = Response("hello")
    resp.set_cookie("user", user_id)
    return resp

def new_id():
    import time
    return str(time.time())

app.run(host="0.0.0.0")
```

dict of cookies

key

key value

#TODO: get better identifiers



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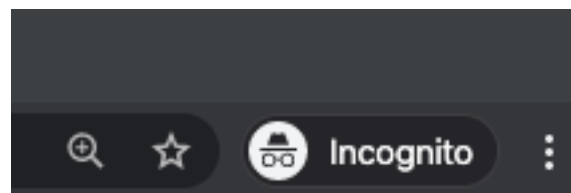
app.run(host="0.0.0.0")
```

dict of cookies

key

key value

#TODO: get better identifiers



More accurate than IP, but cookie churn, incognito mode, and local laws may limit...

# Summary

## Goals

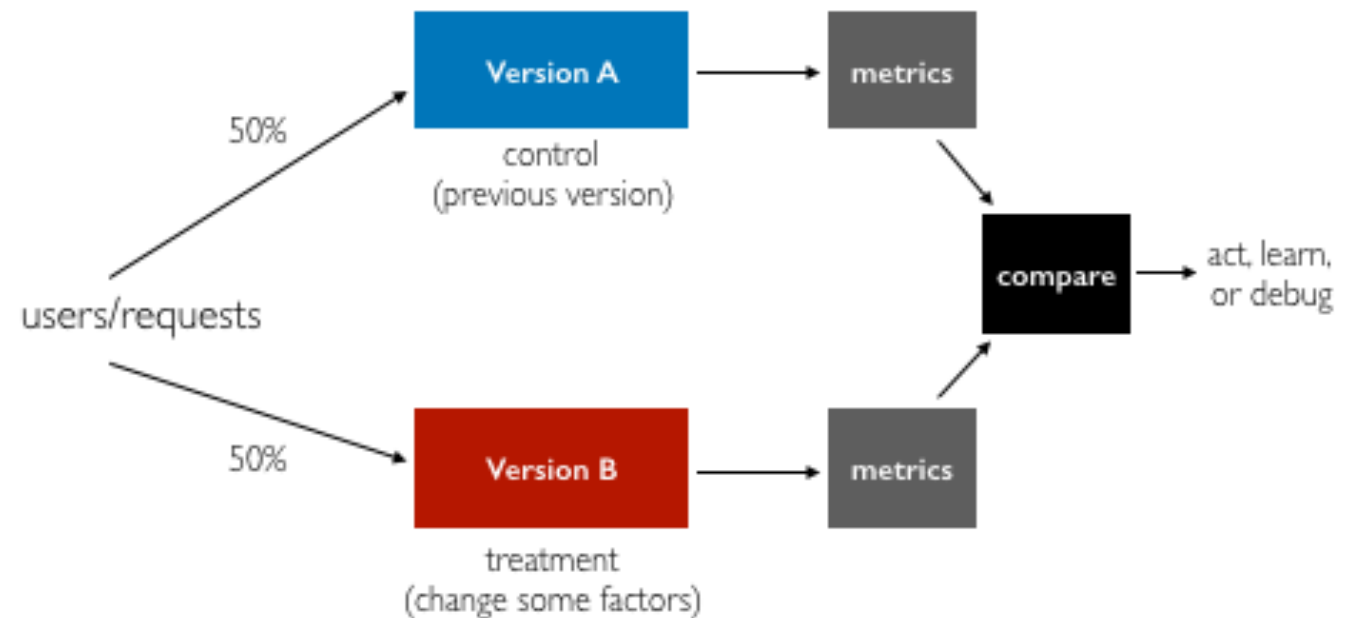
- make decisions, learn, debug

## Comparisons

- significance testing

## Metrics

- simple or combos
- clean uniformly
- choose OEC up front
- think long-term



## Treatments

- one or more factors
- factors may require a lot of coding/design work!
- OFAT usually best for learning
- check the novelty factor with a flipped A/B test after decision

## Splitting Traffic

- ramp up slowly
- split requests or users (how to distinguish?)