

[320] Web 3: A/B Testing

Department of Computer Sciences
University of Wisconsin-Madison

Source for Examples/Lessons

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

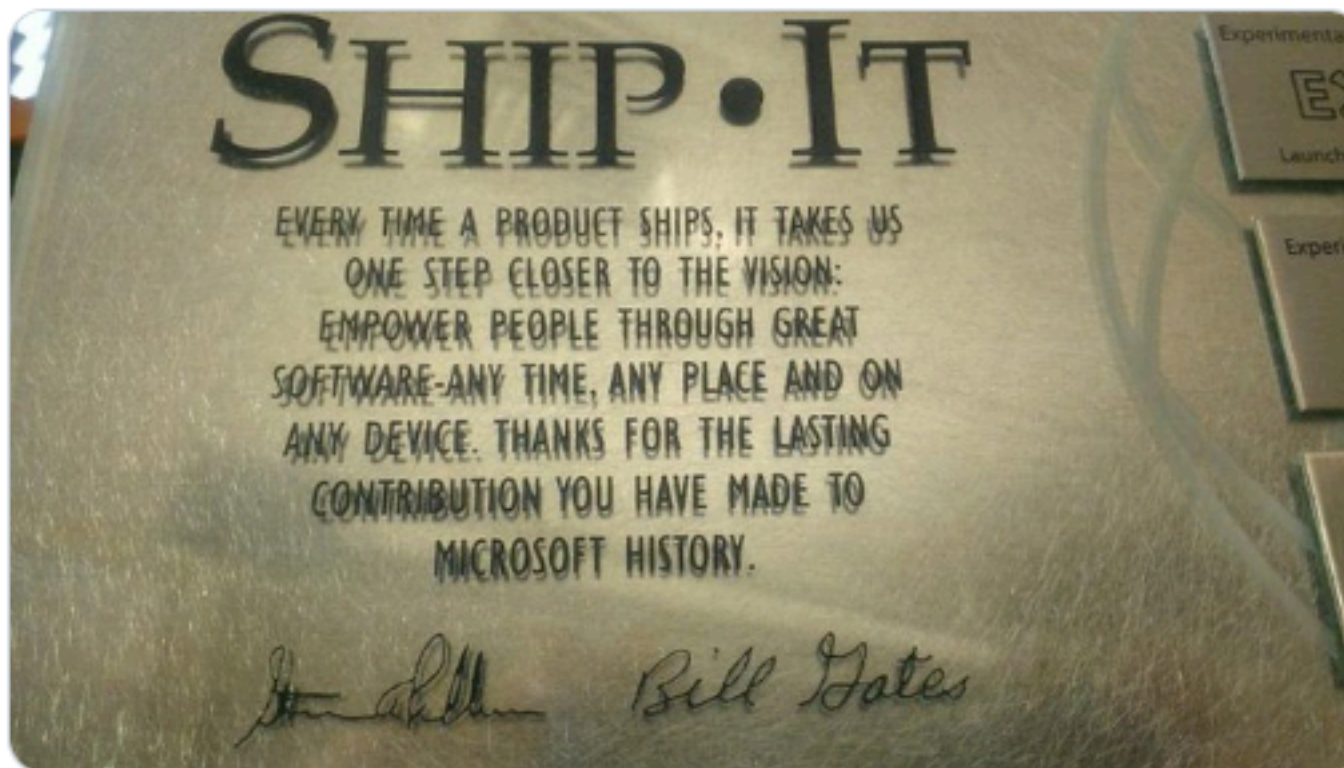
Title: Online Controlled Experiments: Lessons from Running A/B/n Tests for 12 years

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



Ronny Kohavi @ronnyk · Nov 7, 2014

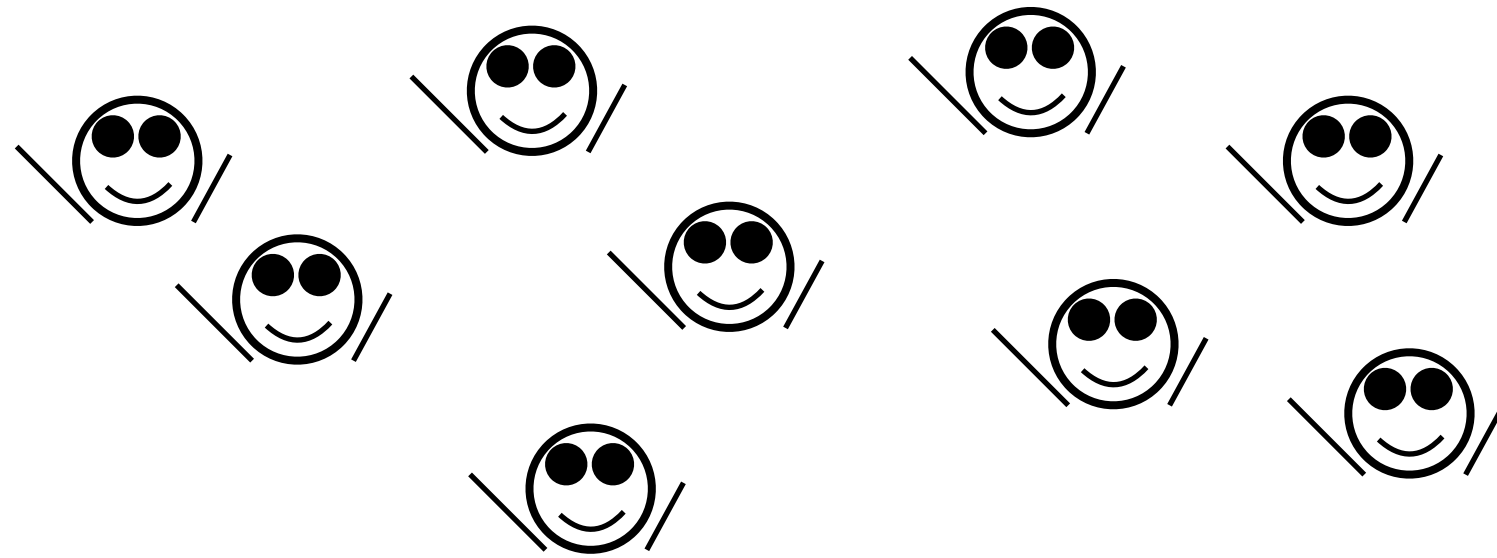
Microsoft stopped ship-it-awards today! With [#abtesting](#), it's about user-impact; NOT shipping is often better!



Experiment Design:

Does Coffee Improve Programming Ability?

programmers:

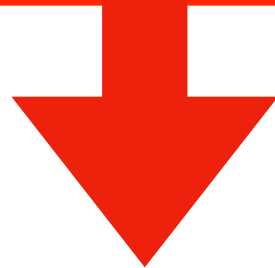
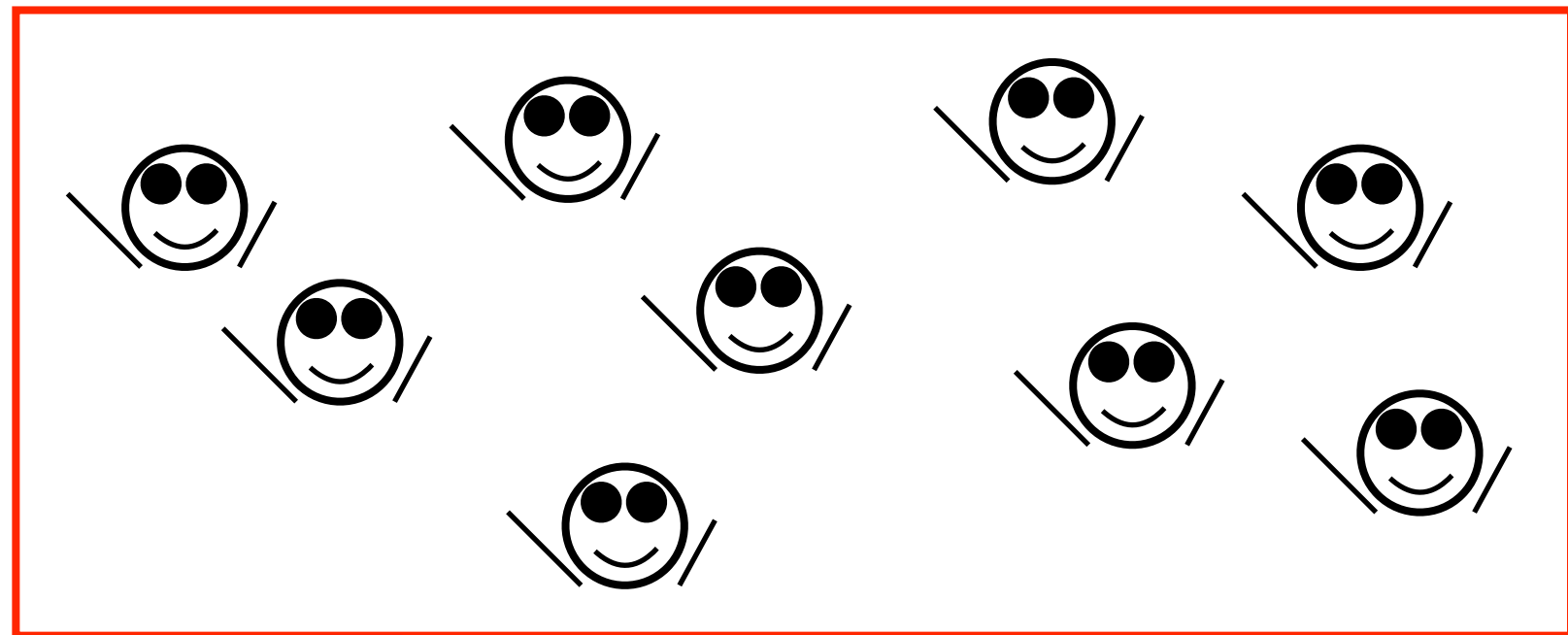


Experiment Design:

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Design I: before and after

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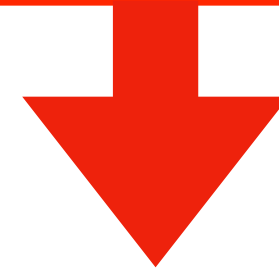
average of 16 hours
for the project before
(no coffee)

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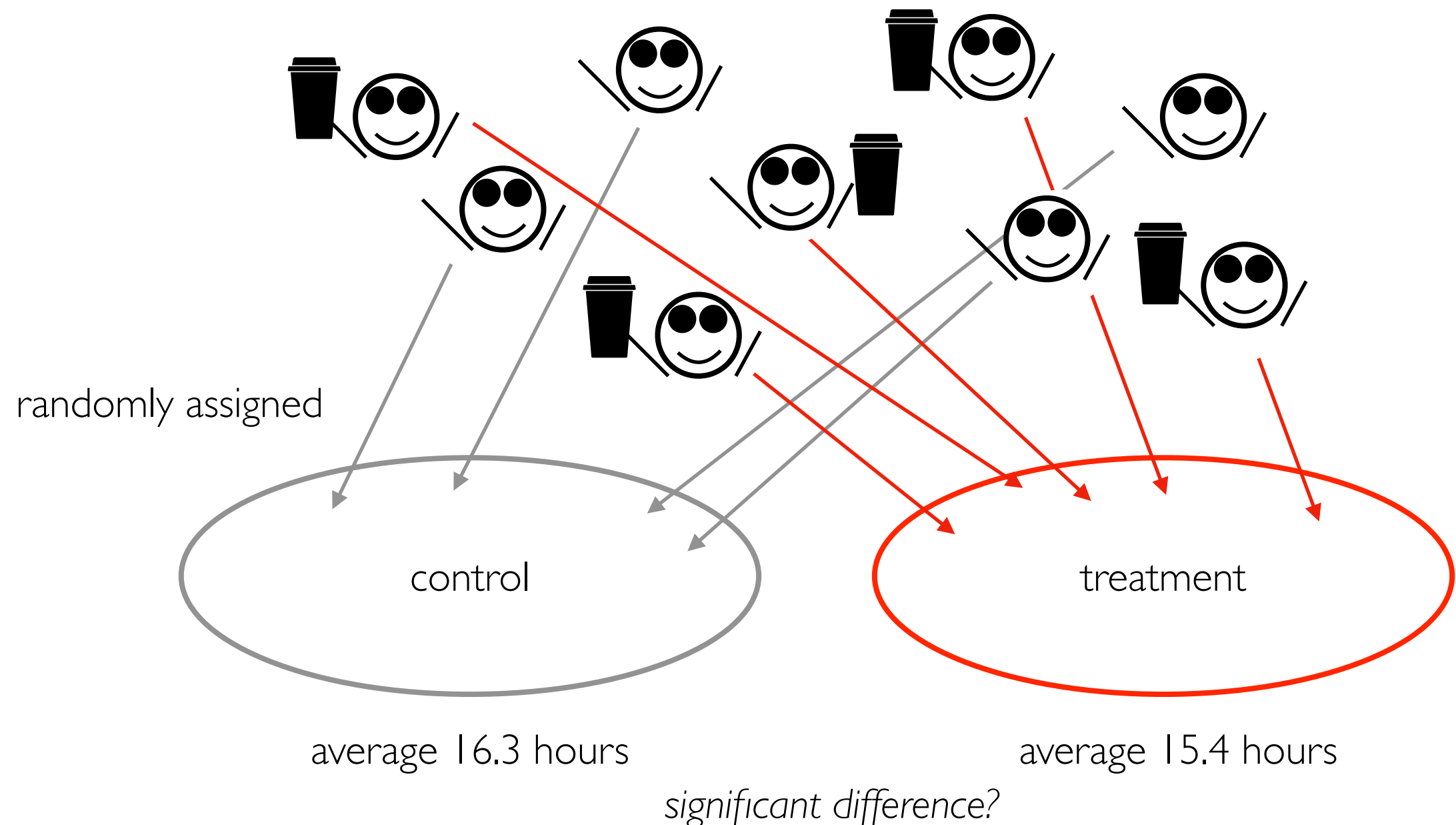
concerns???

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Experiment Design: Does Coffee Improve Programming Ability?

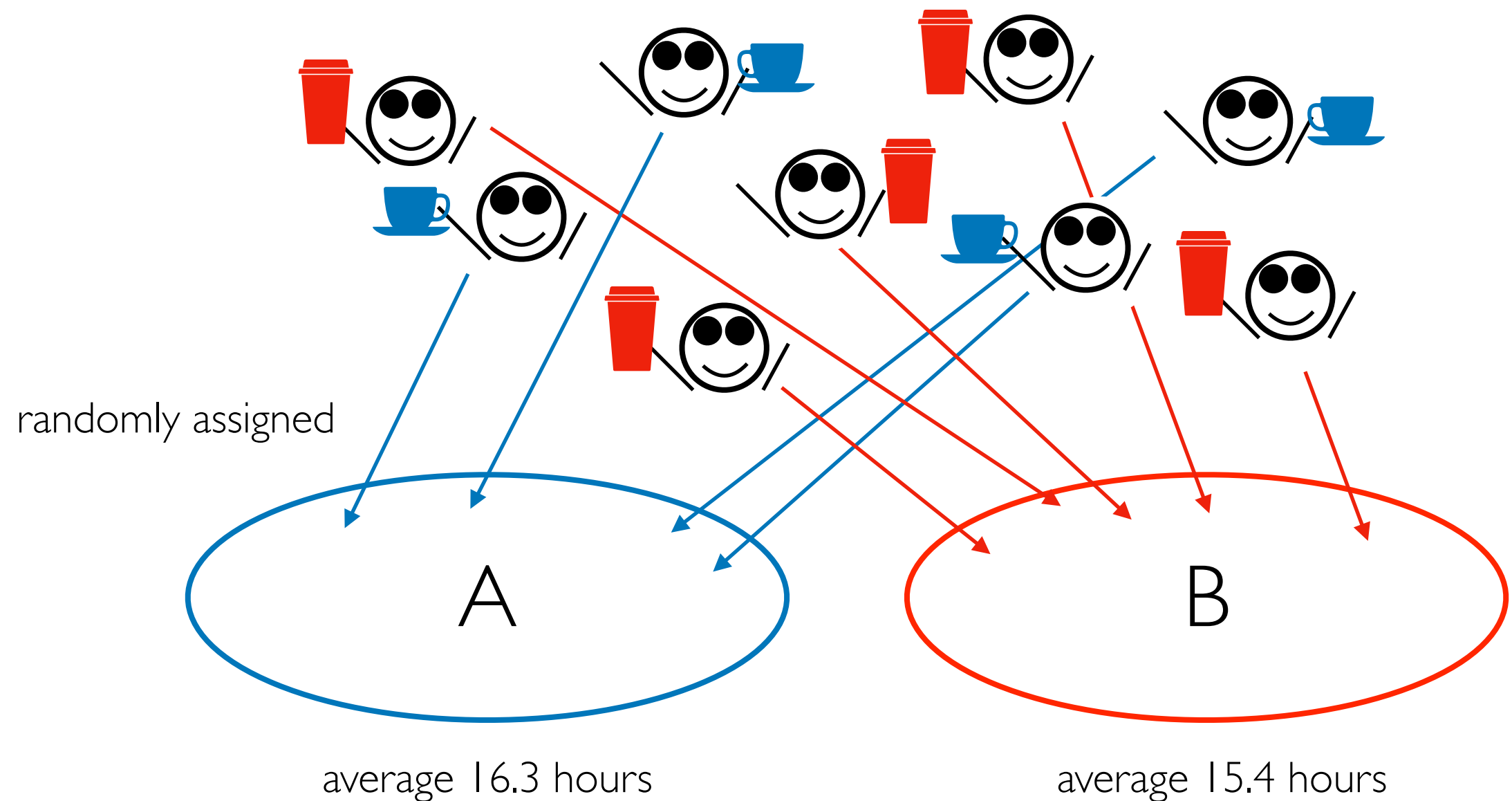
Design 2: randomly assigned control and treatment groups



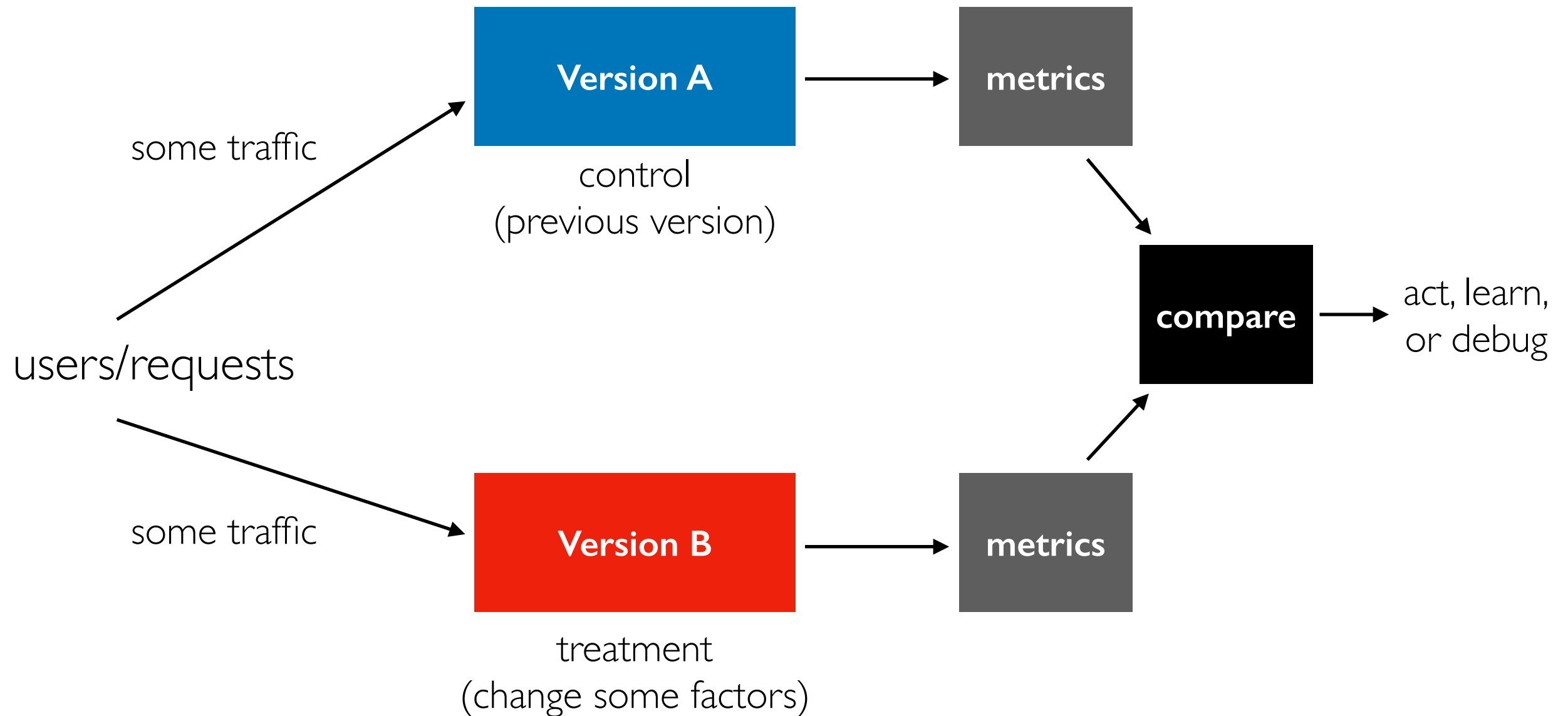
Experiment Design:

Is coffee or tea better for programming?

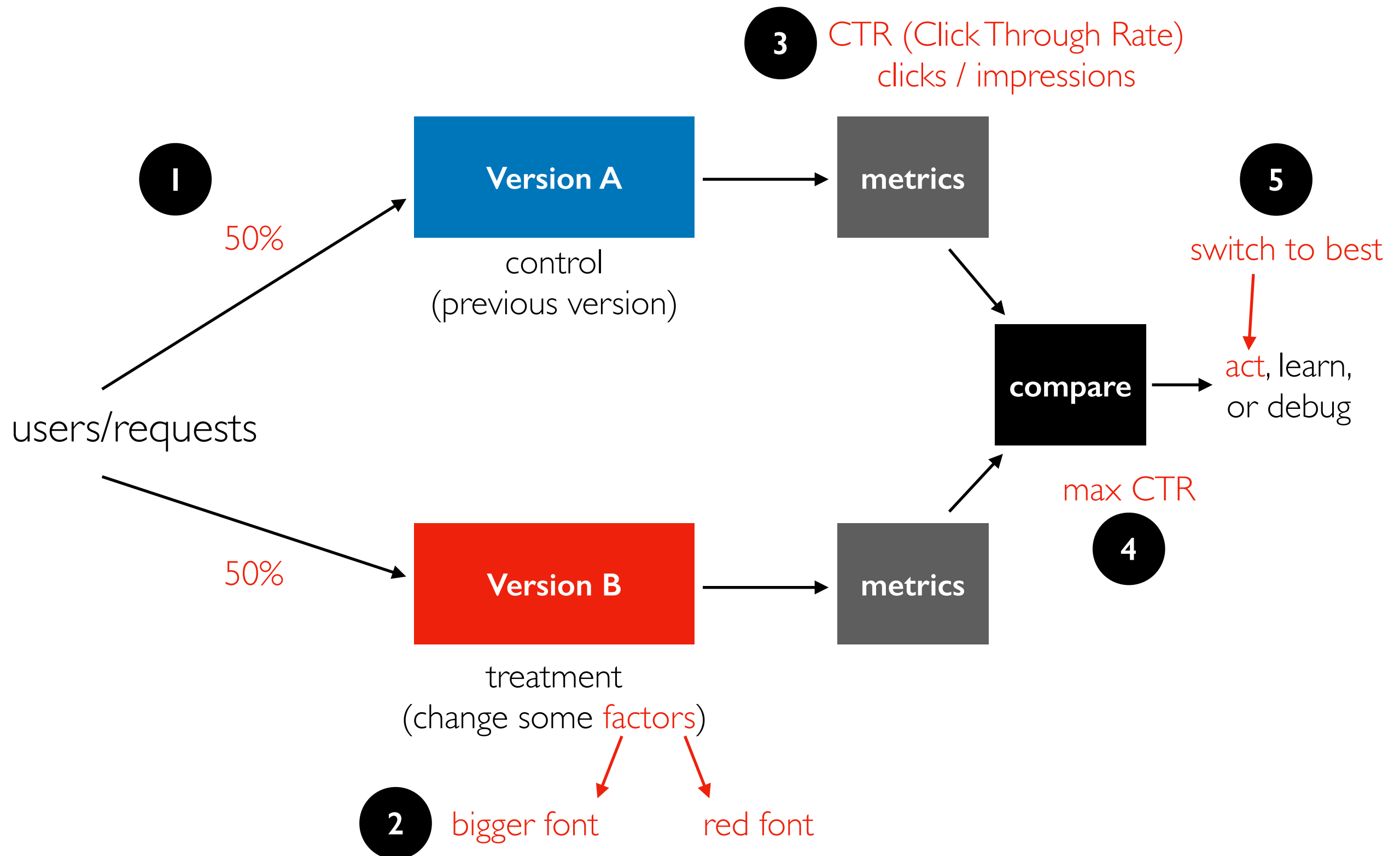
A/B Testing



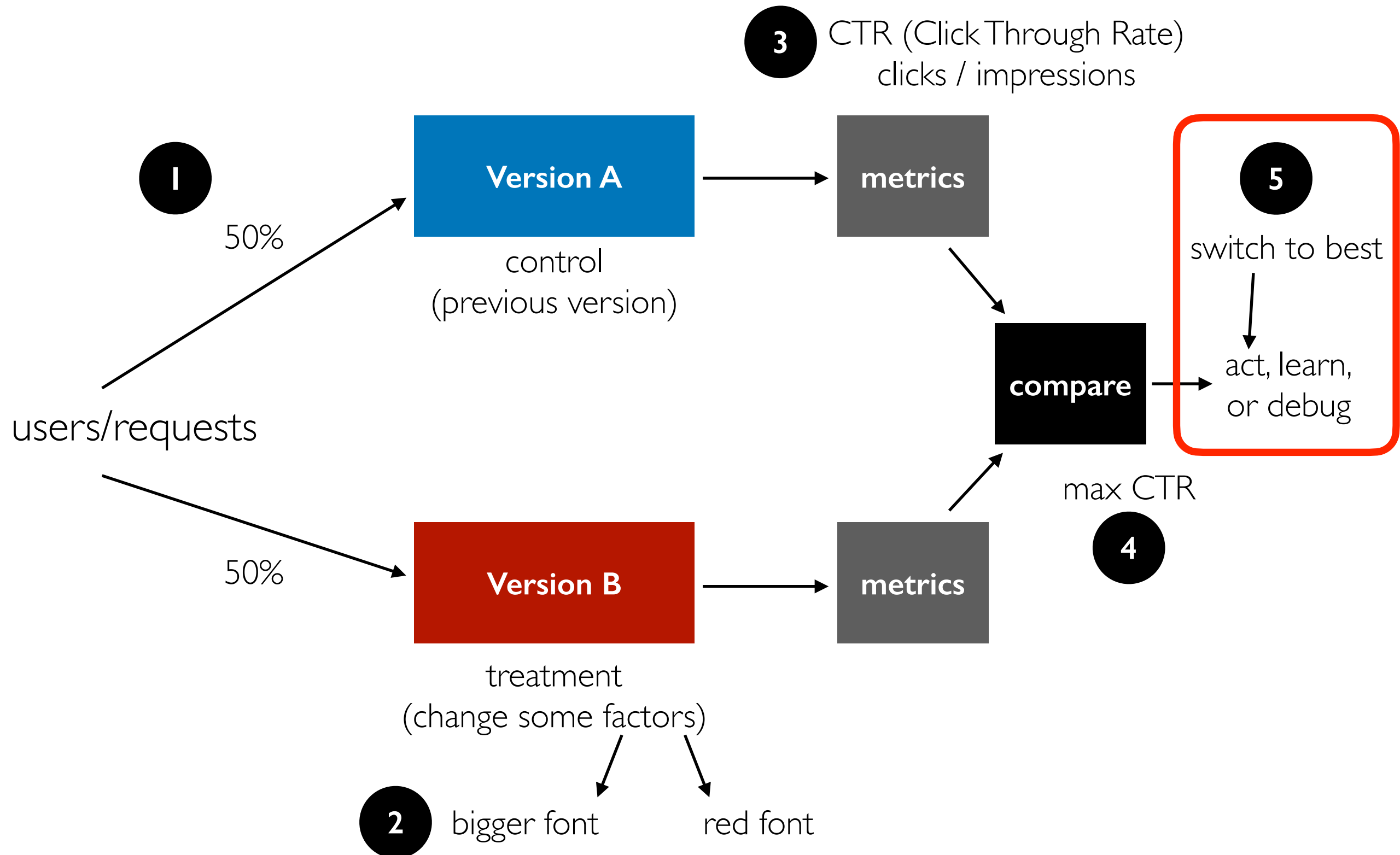
A/B Test Overview (for web applications!)



Example I: Link to Donation Page

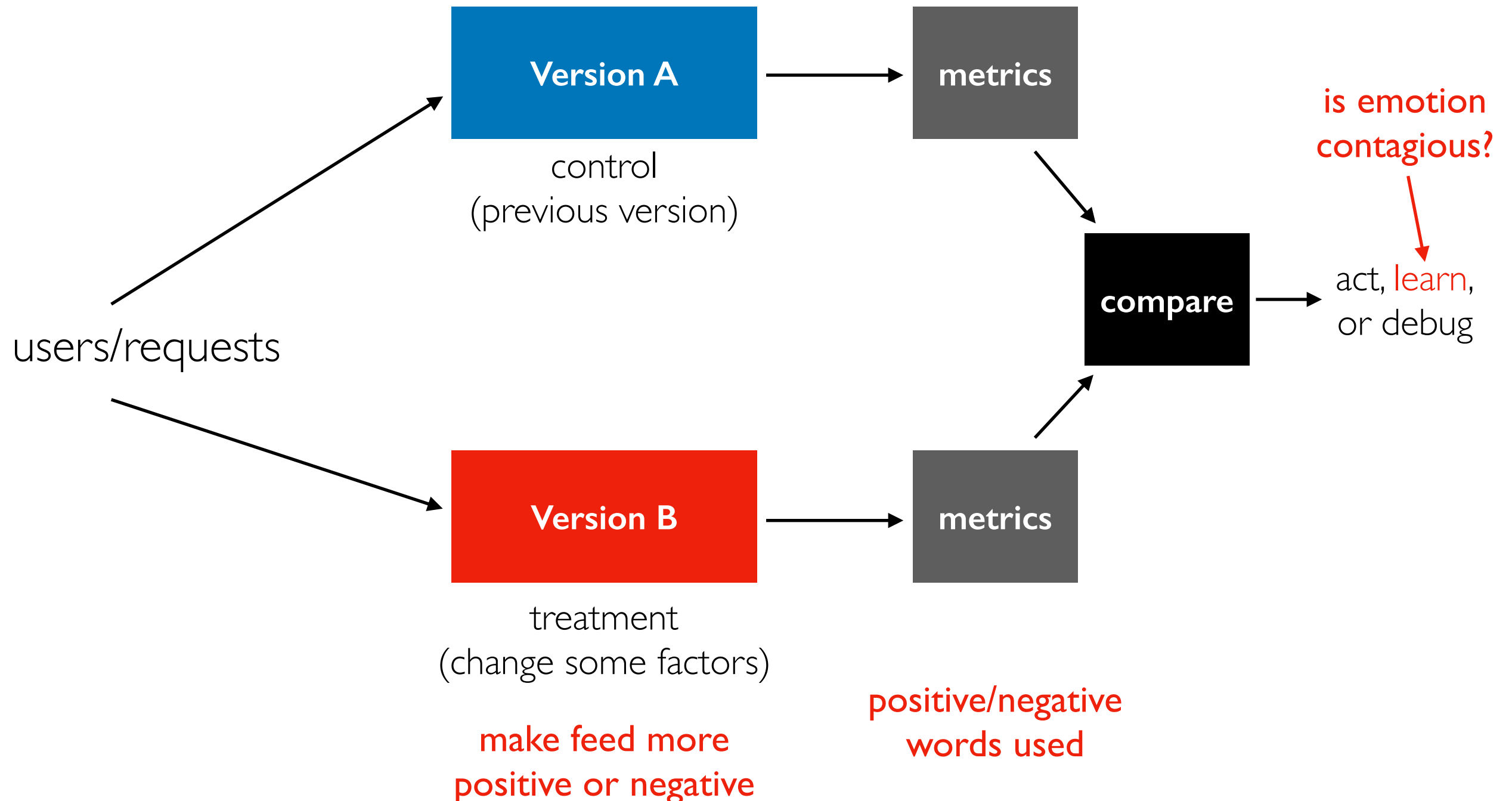


Lecture Outline



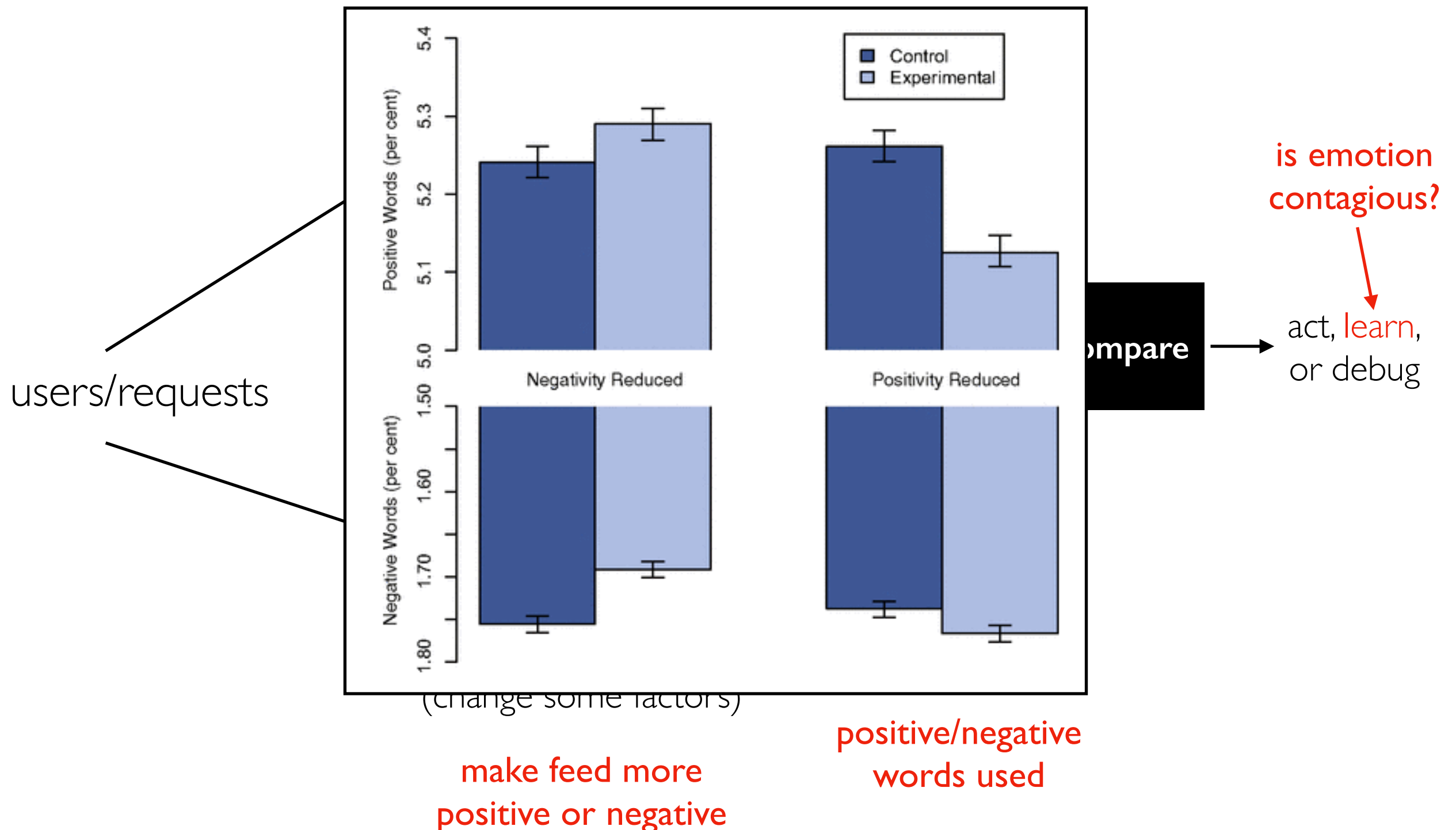
Example 2: Facebook Emotional Contagion Study

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



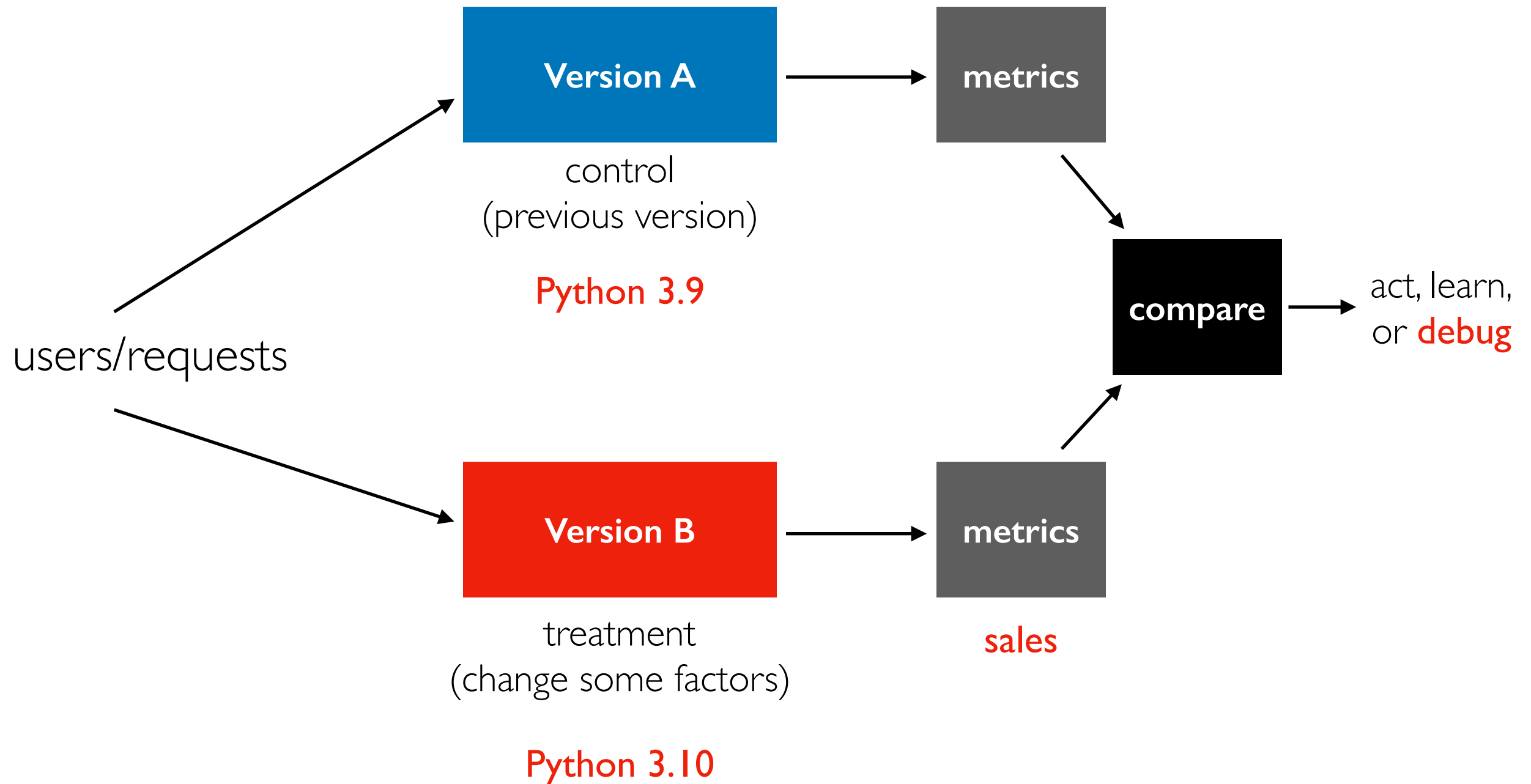
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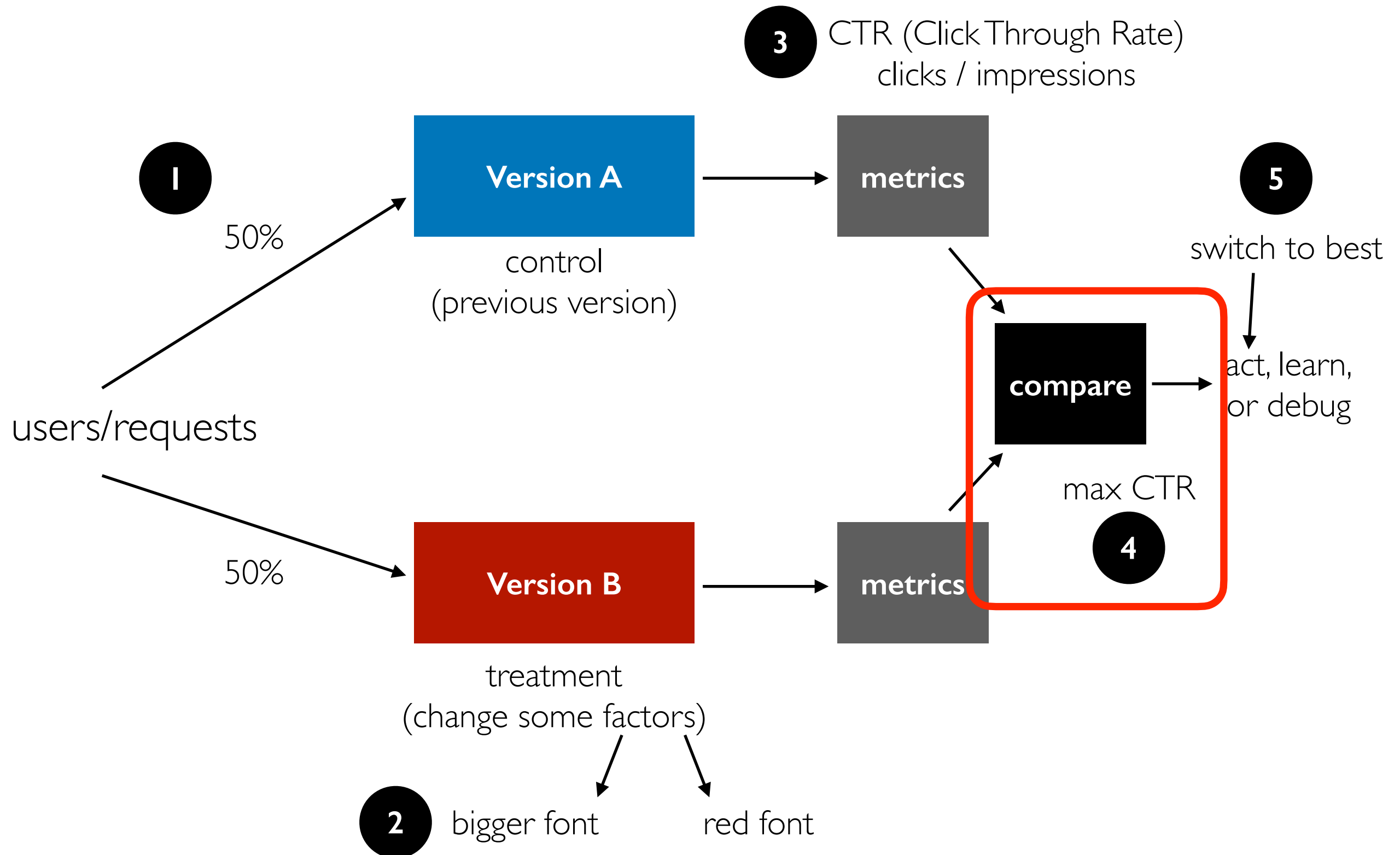


didn't need to submit to the IRB (Institutional Review Board) -- *when should it be required?*

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**? $6/20 = 30\%$

Comparisons

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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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df: contingency table

pip3 install scipy

```
1 import scipy.stats as stats
2 _, pvalue = stats.fisher_exact(df)
3 pvalue
```

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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*out of 200 neutral changes, how many
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*occasionally run A/A tests to make
sure the system is working (false
positive rate should be as expected)*

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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, there are tabs for 'ALL', 'SHOPPING', 'IMAGES', 'VIDEOS', 'MAPS', and 'NEWS'. The 'ALL' tab is selected. The results show 196,000,000 Results and a filter for 'Any time'. The first result is 'Amazon.com - Amazon.com® Official Site' with a URL 'https://www.amazon.com'. Below the title, there is an advertisement for Amazon.com, stating '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'. Below the ad, there are four links: 'Shop Echo & Alexa Devices', 'Amazon Prime Benefits', 'Learn More About Alexa', and 'Shop Amazon Fire Tablets'. Each link has a brief description. At the bottom, there is a link 'Meet the Fire TV Family' and a link 'See results only from amazon.com'. The second result is 'Amazon.com: Online Shopping for Electronics, Apparel ...' with a URL 'https://www.amazon.com'. Below the title, there is a description of the site, stating '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 & ...'. Below the description, there is a rating of 5/5 stars (1) and a price of \$21.06. At the bottom, there are two links: 'Sign In' and 'Books'. Each link has a brief description. A 'See more' link is at the bottom left.

amazon

ALL SHOPPING IMAGES VIDEOS MAPS NEWS

196,000,000 Results Any time

[Amazon.com - Amazon.com® Official Site](#)
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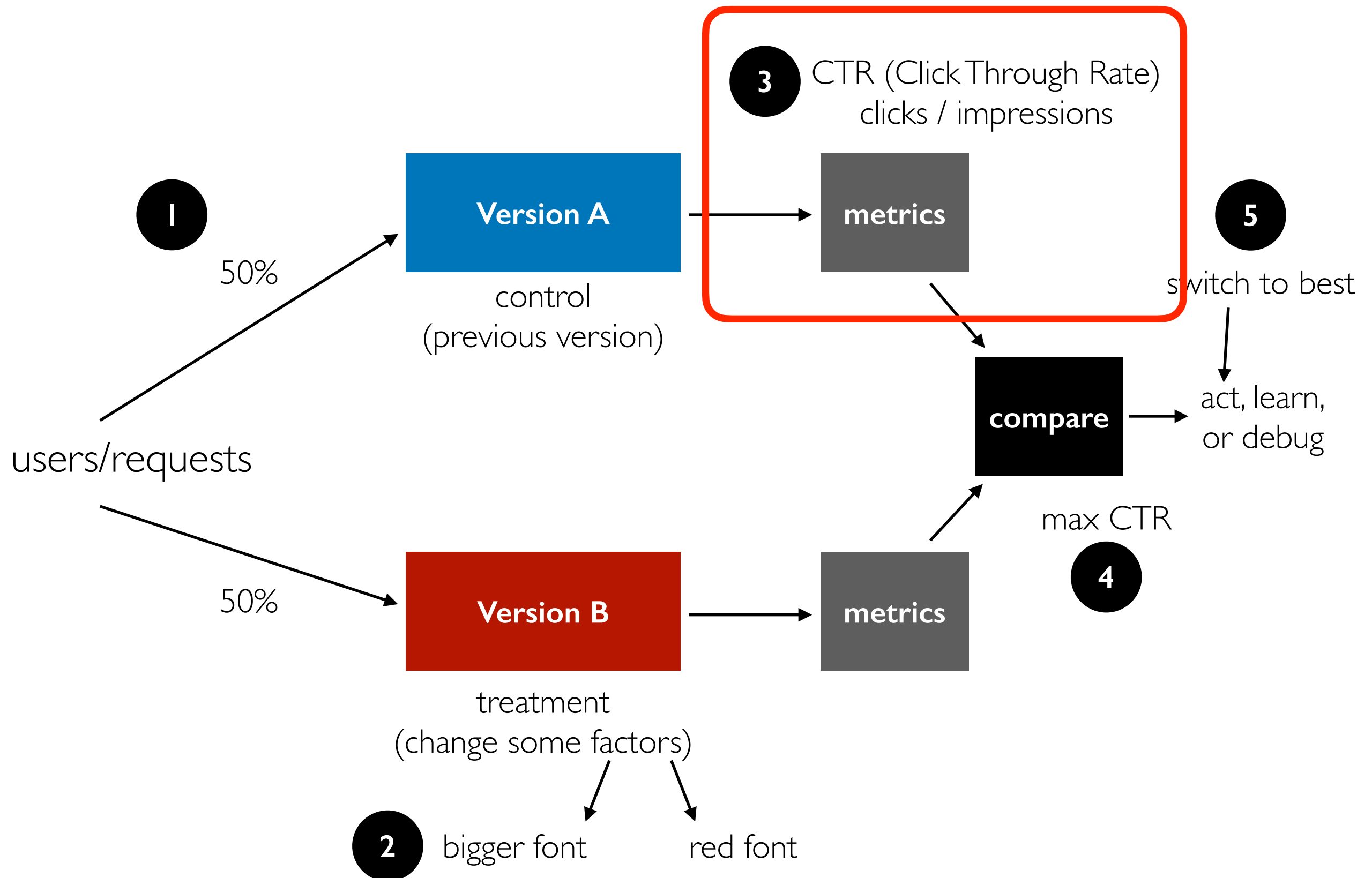
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Lesson: metrics should inform humans, not directly determine decisions

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?)
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- 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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what is the effect of B?

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

what is the effect of B?

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Things to measure:

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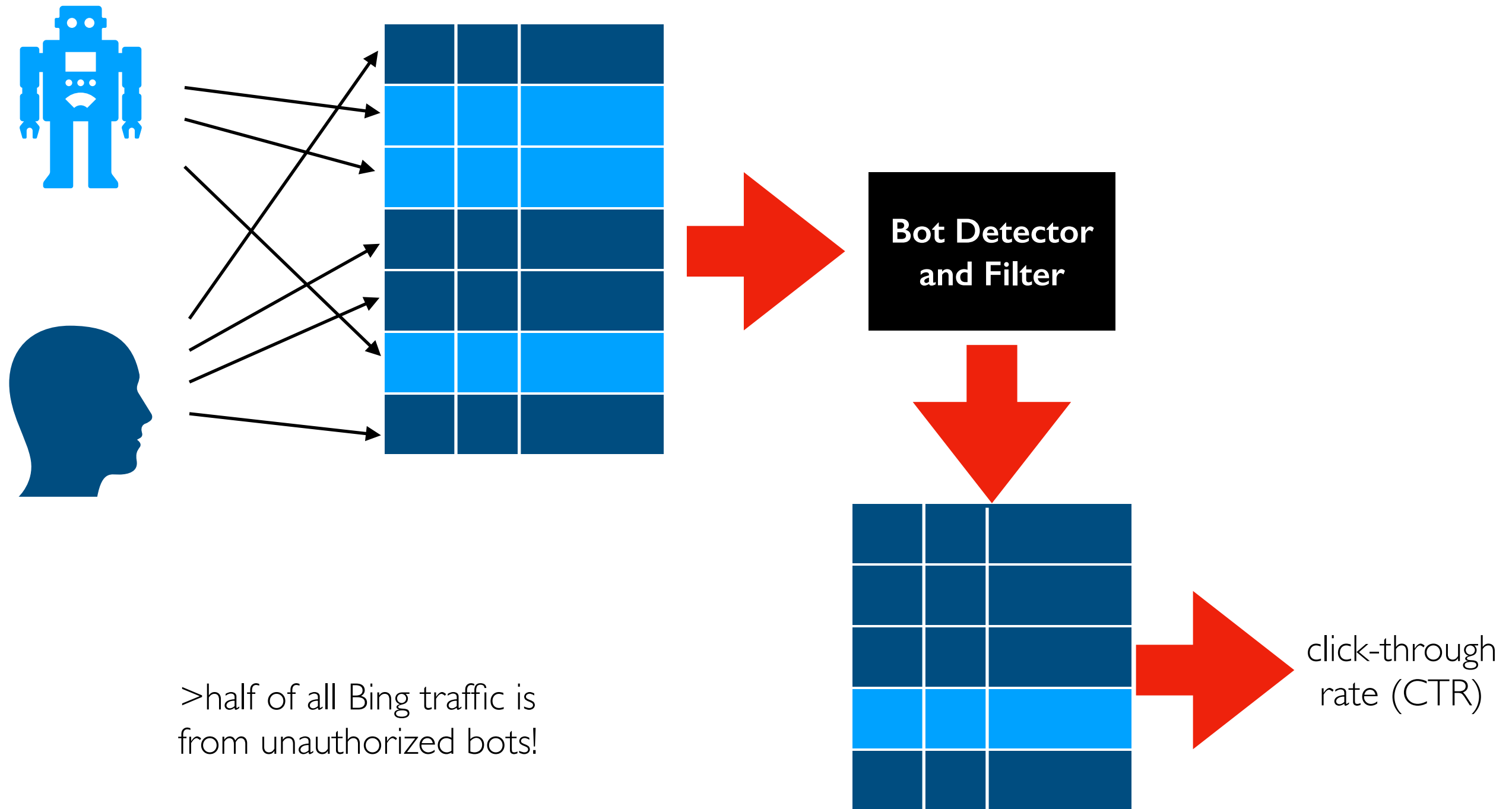
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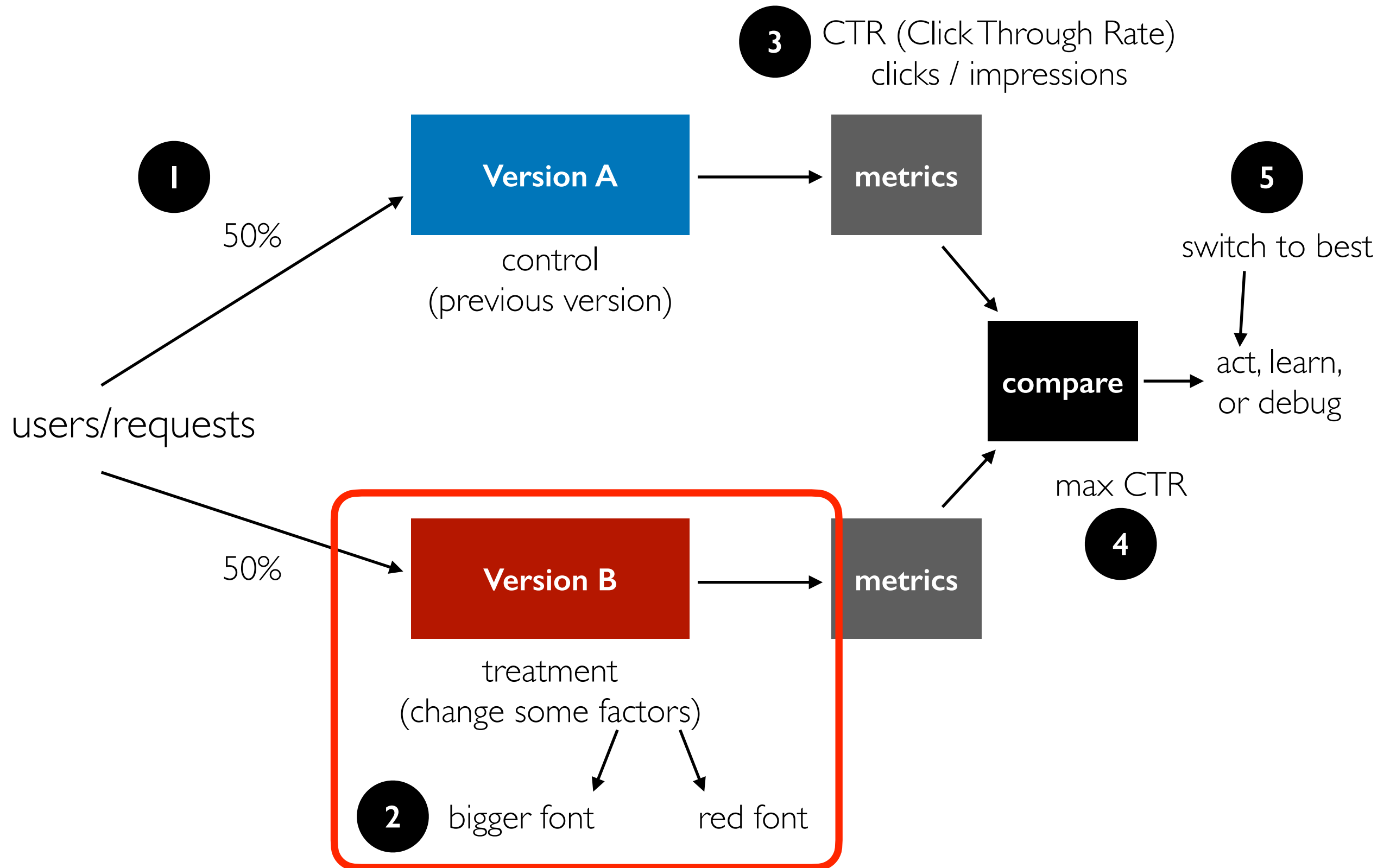
Decide beforehand on one **OEC** metric: Overall Experiment Criterion

- 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?

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- slowdown
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- 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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many experiments are big time investments (require significant coding)!

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

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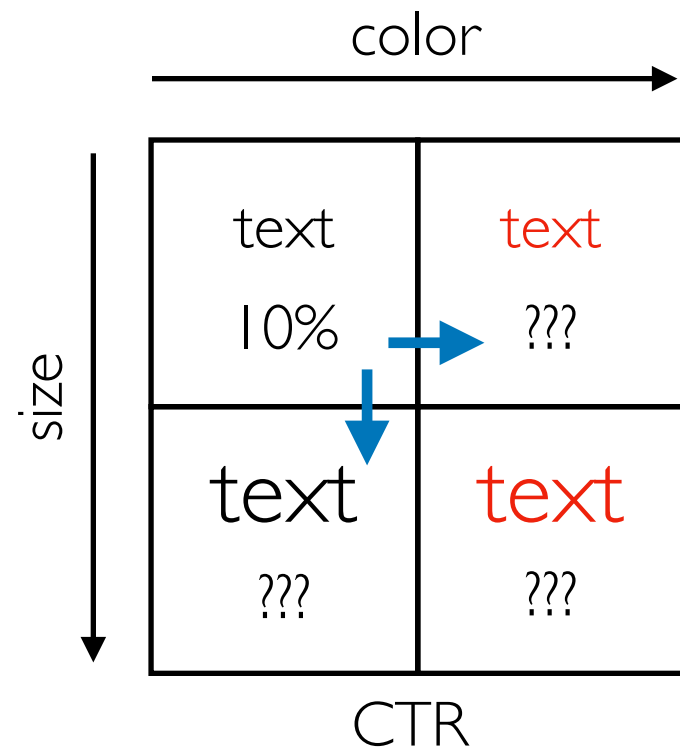
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Lesson: don't be too attached to your work, be redundant and ready to throw things away

there's also plenty of low-hanging fruit!

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

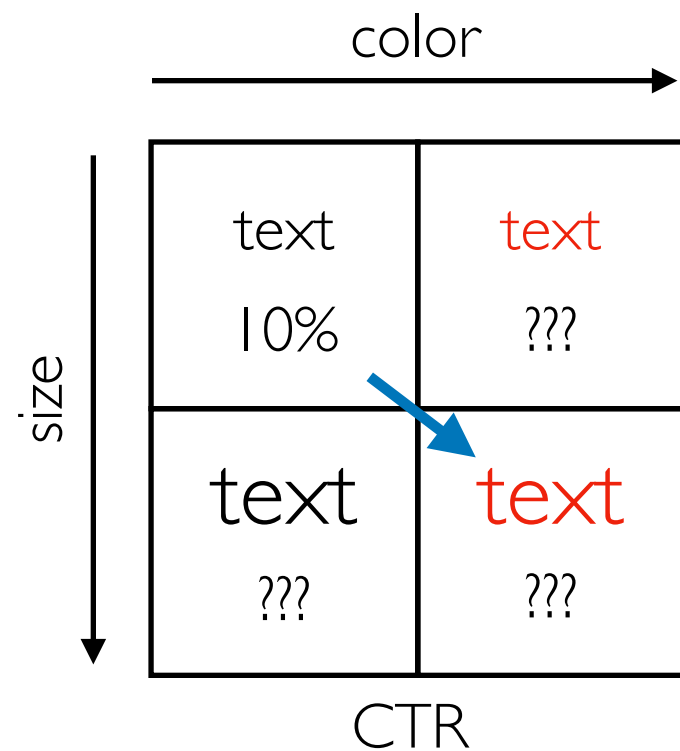
Finding the Best Combination



Option I: OFAT (one factor at a time)

Hypothesis: large red
font will be better

Finding the Best Combination

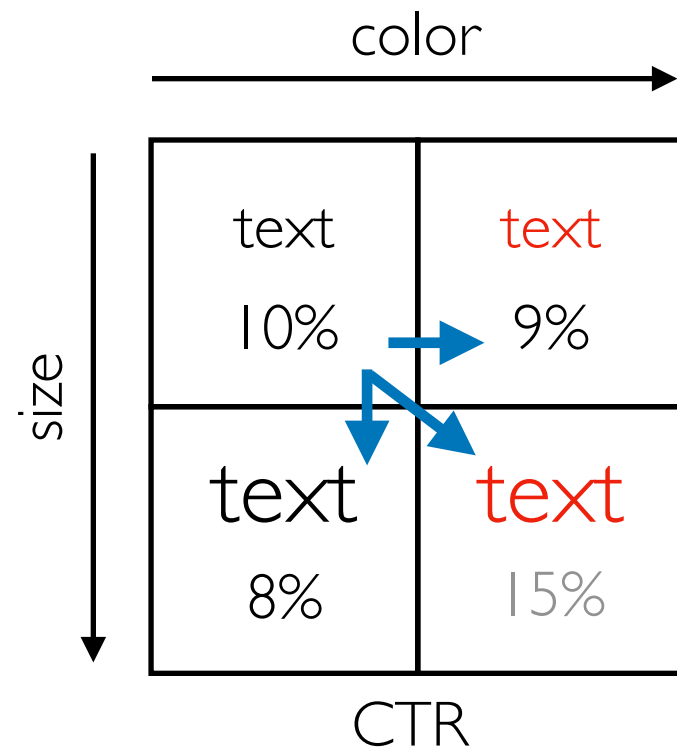


Option 1: OFAT (one factor at a time)

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

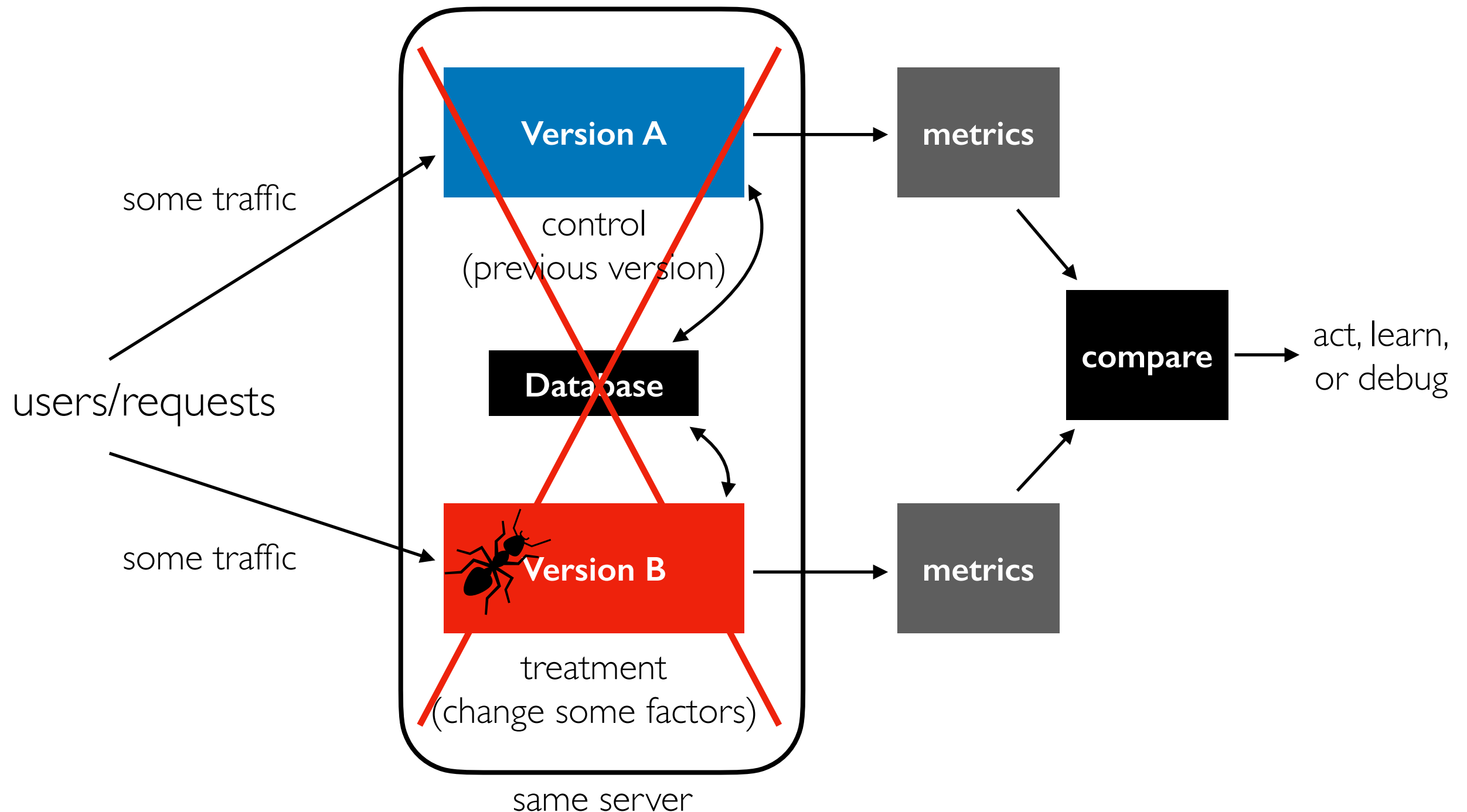
Option 1: OFAT (one factor at a time)

can usually learn more, but will never exploit factor interactions

Option 2: introduce two factors at once

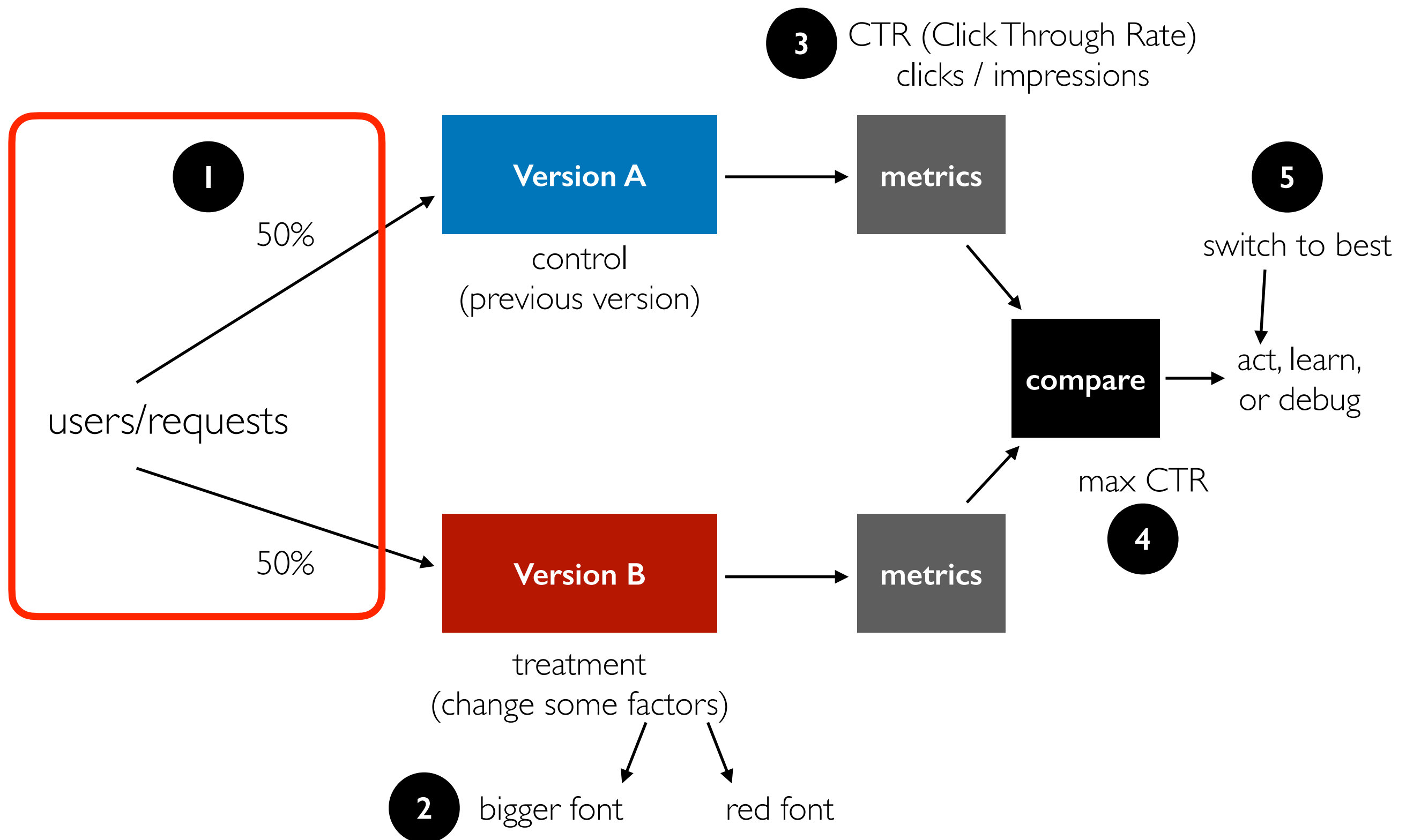
can choose a good design, but didn't learn what factors are important

Control/Treatment Disruptions



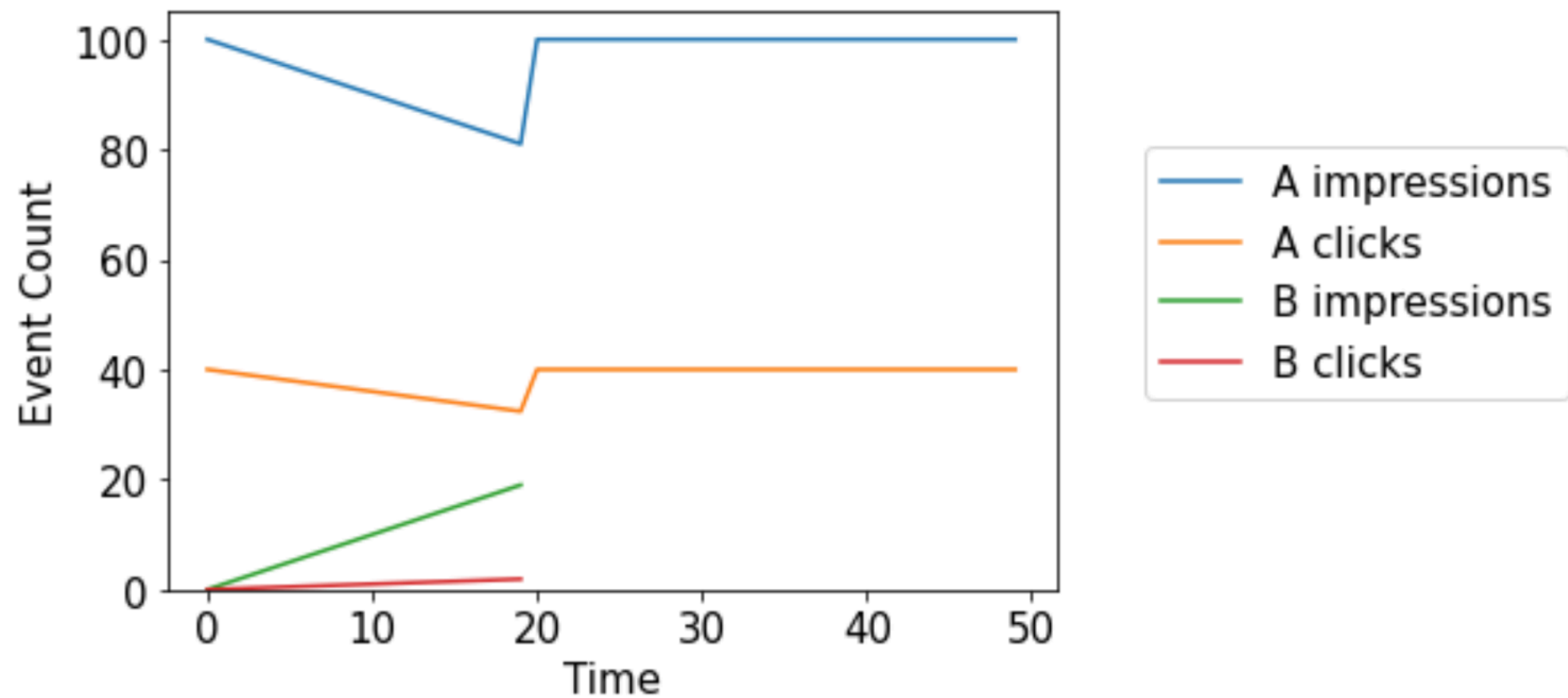
Different variants may save databases/servers, affecting performance of both. Bugs crashing the server will be especially bad! Metrics won't show the true blame.

Lecture Outline

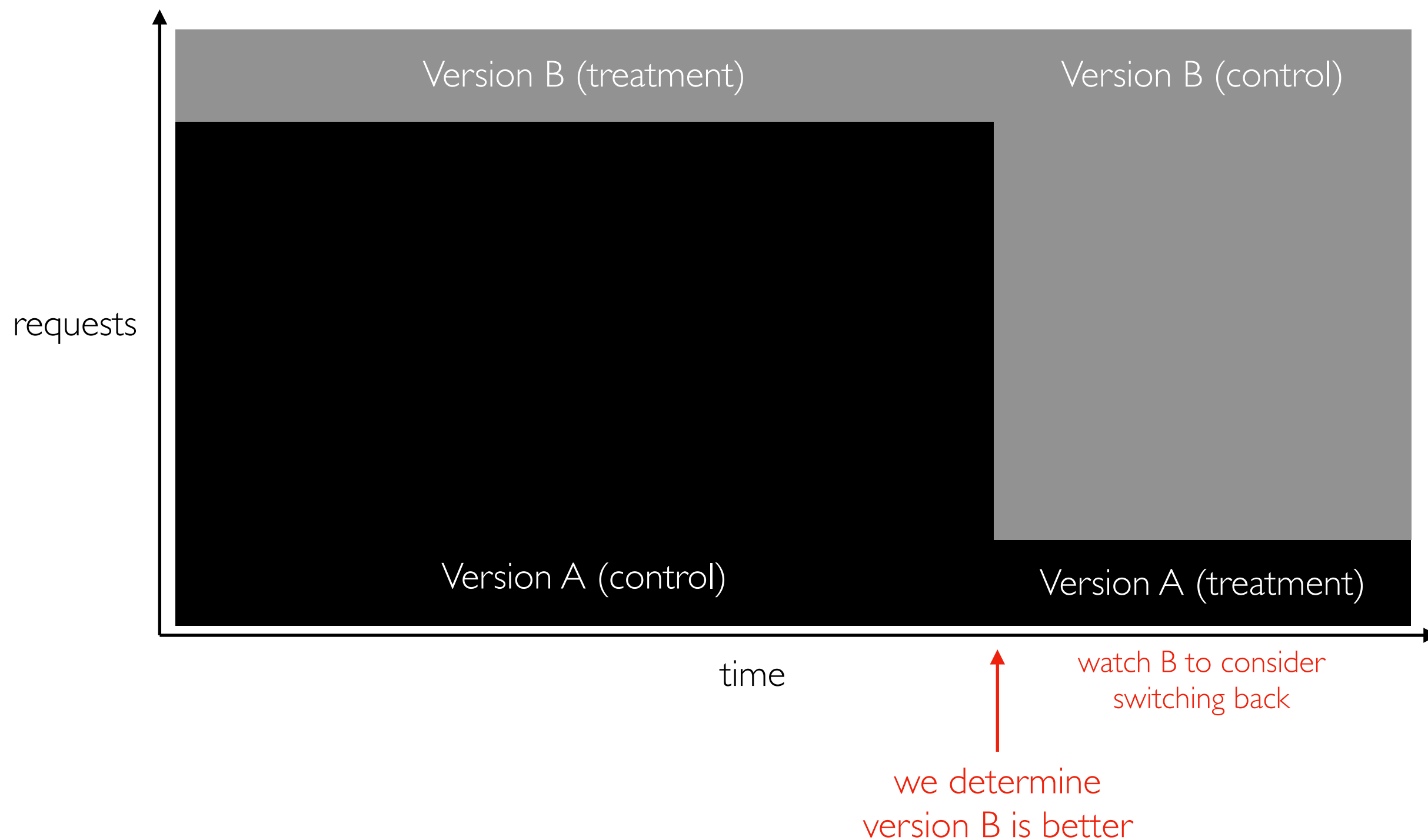


What to split

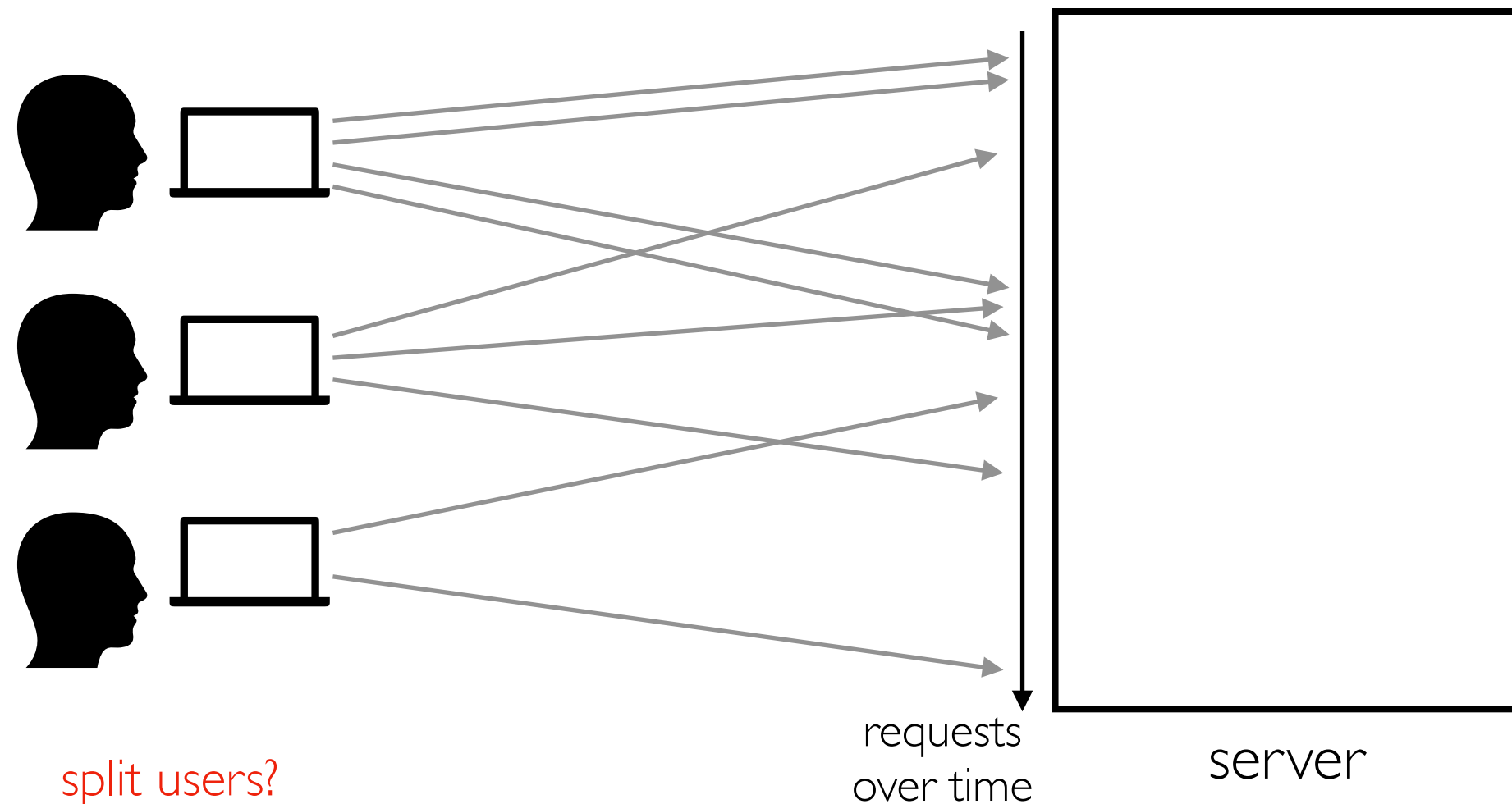
Don't go straight to 50/50!



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



What to split between control+reatment?



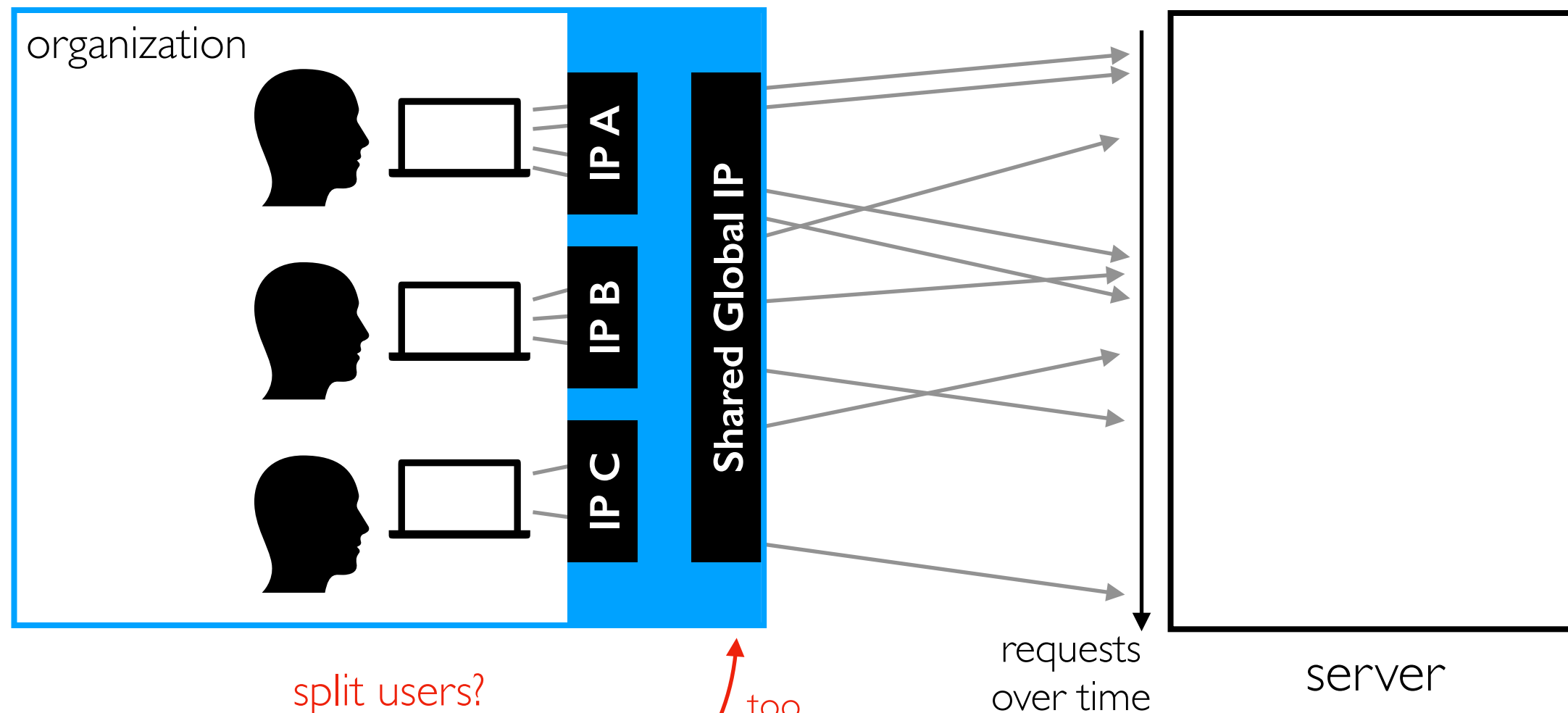
how to identify?

- 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?

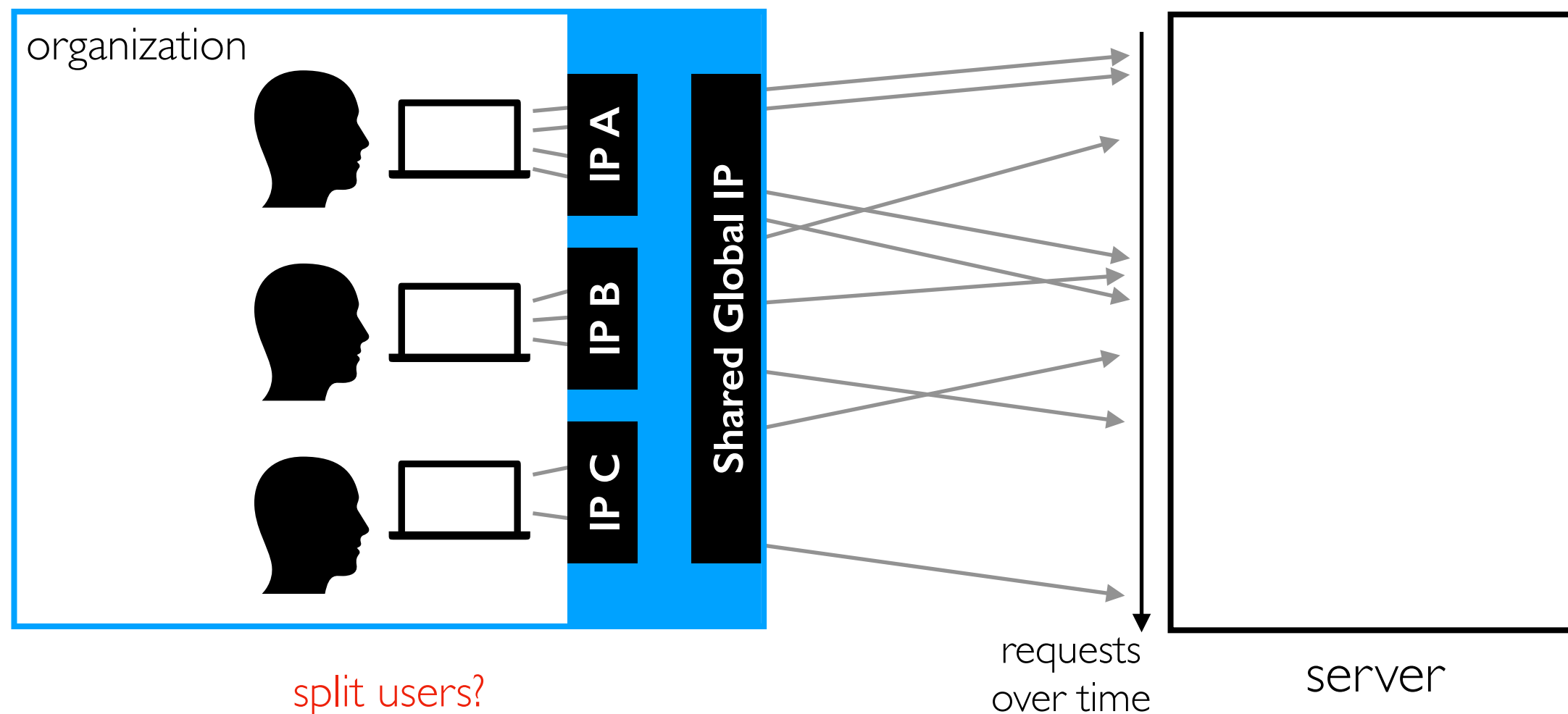
- IP addresses
- signed-in services
- cookies

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?

requests
over time

server

how to identify?

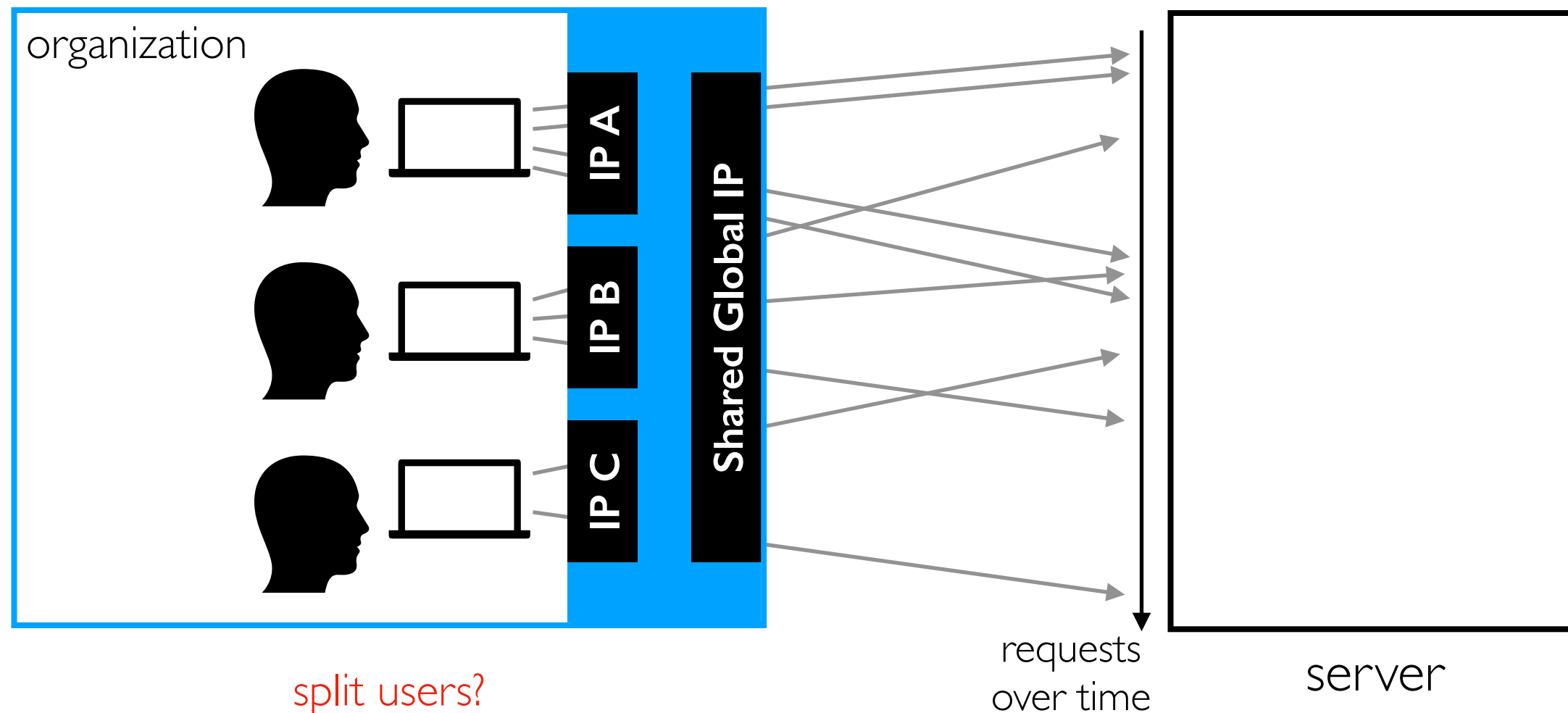
- IP addresses
- signed-in services
- cookies

or requests?

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

ideal for when
applicable

What to split between control+reatment?



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

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

Cookies

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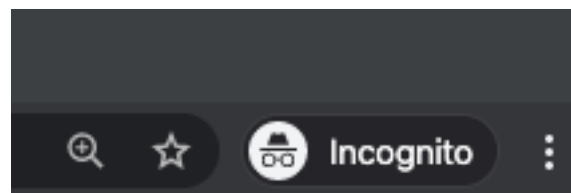
app.run(host="0.0.0.0")
```

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

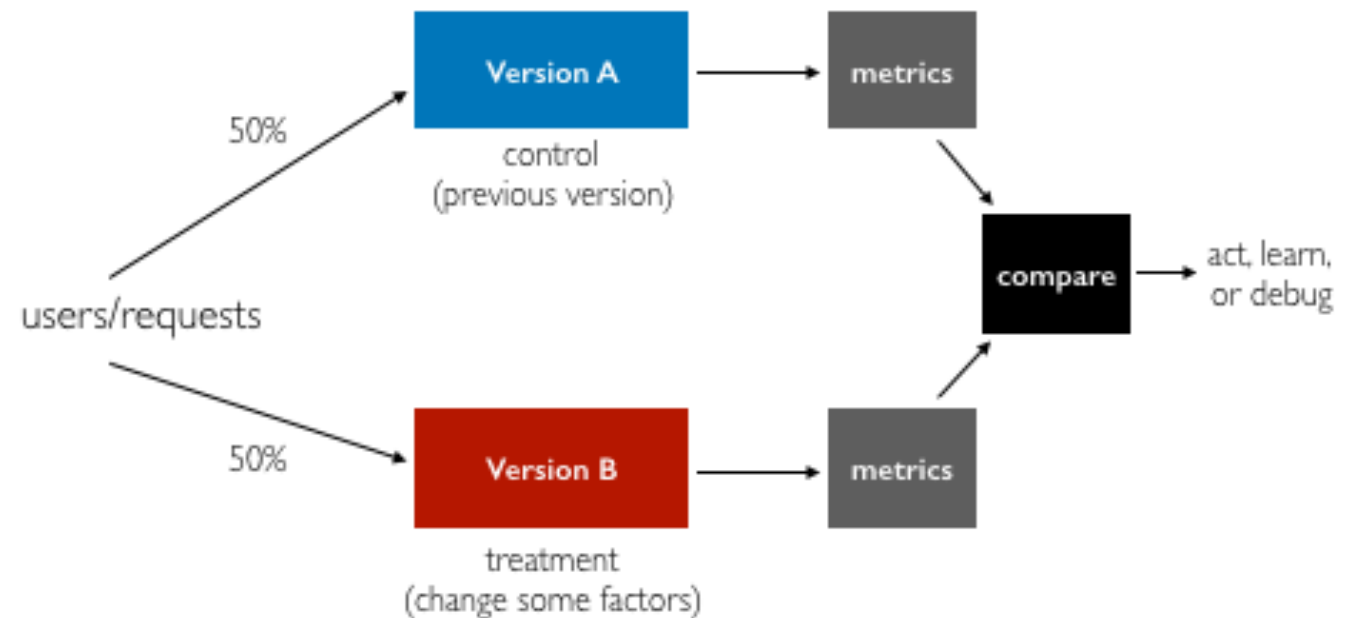
- make decisions, learn, debug

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?)