Building a **Personalized Messaging System** at Netflix

Grace Huang
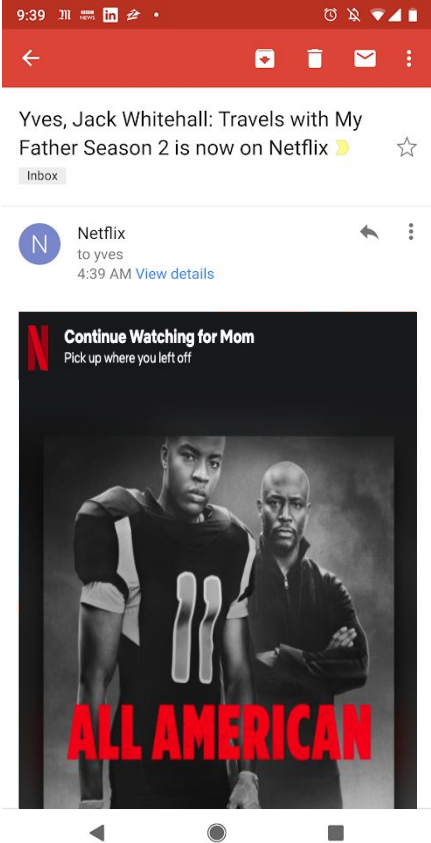July 31th, 2020
Data Council SF 2020

DOES IT SPARK JOY?

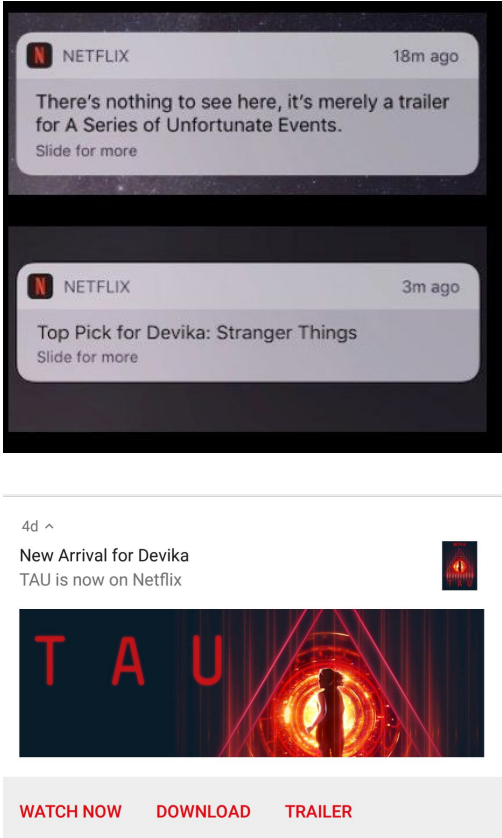When members find content they love, they enjoy our service more

Our messages are designed to help them find content to enjoy

Some ways to reach out to our members

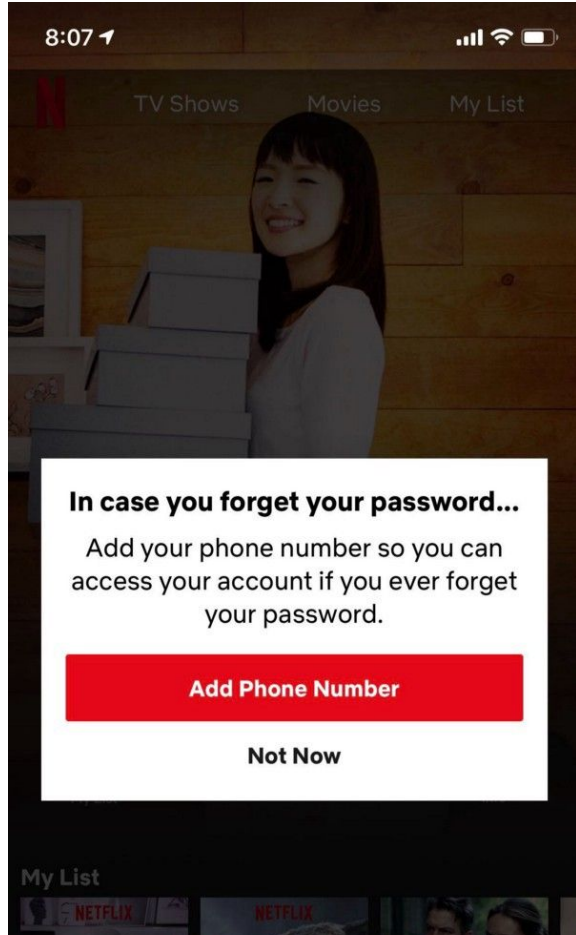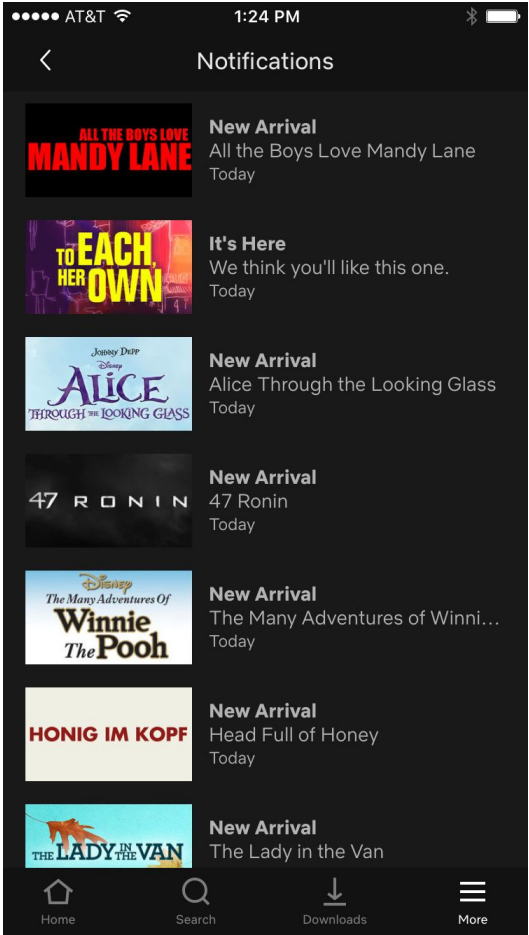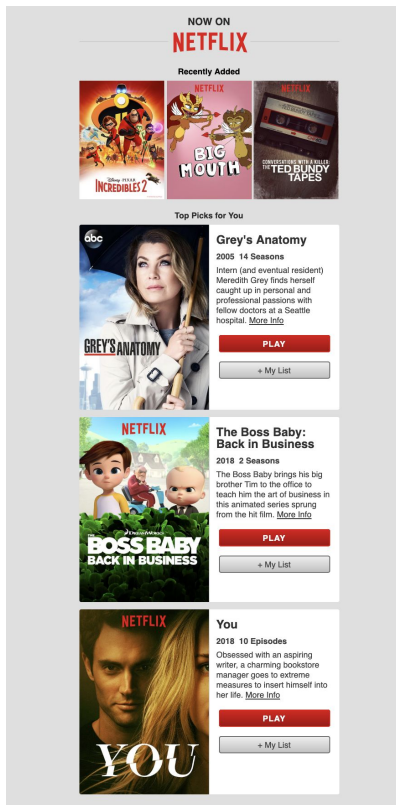## Email

Push

SMS

In-App: Notifications and Alerts
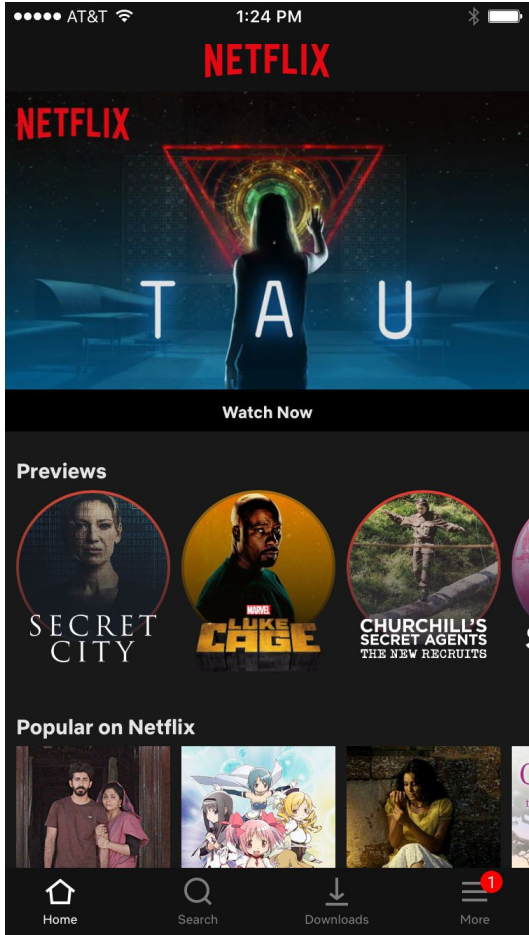
A Variety of Message Types
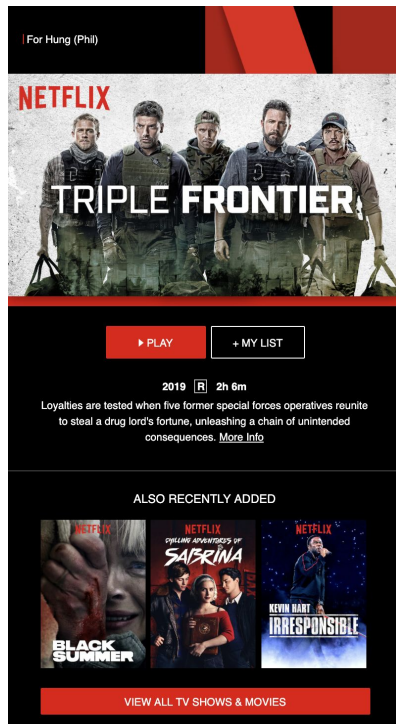
NOW ON
NETFLIX

Recently Added

Top Picks for You

Grey's Anatomy
2005 14 Seasons
Intern (and eventual resident)
Meredith Grey finds herself
caught up in personal and
professional passions with
fellow doctors at a Seattle
hospital. More Info

PLAY
+ My List

**The Boss Baby:
Back in Business**
2018 2 Seasons
The Boss Baby brings his big
brother Tim to the office to
teach him the art of business in
this animated series sprung
from the hit film. More Info

PLAY
+ My List

You
2018 10 Episodes
Obsessed with an aspiring
writer, a charming bookstore
manager goes to extreme
measures to insert himself into
her life. More Info

PLAY
+ My List

For Hung (Phil)

NETFLIX

TRIPLE FRONTIER

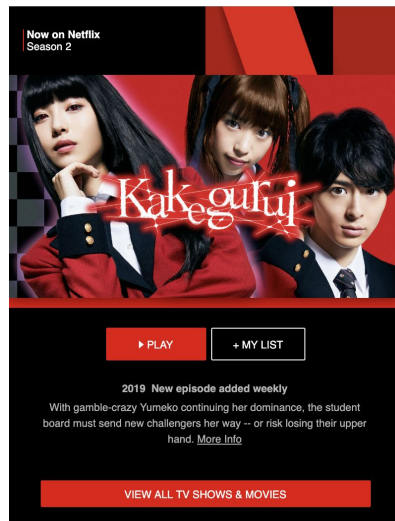**▶ PLAY**   **+ MY LIST**

2019 R 2h 6m

Loyalties are tested when five former special forces operatives reunite
to steal a drug lord's fortune, unleashing a chain of unintended
consequences. More Info

ALSO RECENTLY ADDED

BLACK SUMMER   **SABRINA**   **KEVIN HART IRRESPONSIBLE**

VIEW ALL TV SHOWS & MOVIES

Now on Netflix
Season 2

Kakegurui

▶ PLAY   **+ MY LIST**

2019 New episode added weekly

With gamble-crazy Yumeko continuing her dominance, the student
board must send new challengers her way -- or risk losing their upper
hand. More Info

VIEW ALL TV SHOWS & MOVIES

●●●●○ AT&T 🛜   🔒   100% 🔋
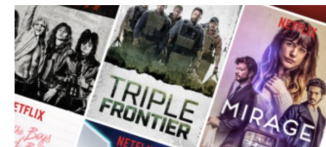
9:41

Tuesday, September 13

N Netflix   now

Mirage, The Dirt, and more.

N Netflix

Coming Soon: 44 New Titles
Mirage, The Dirt, and more.

N Netflix

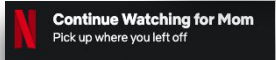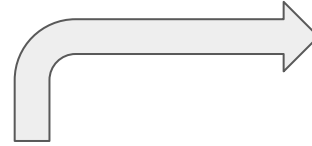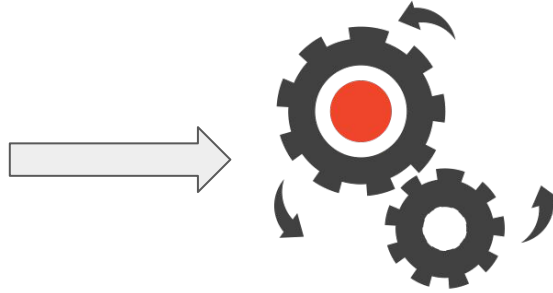**Coming Soon: 44 New Titles**
We think you're going to like these.

TRIPLE FRONTIER   **MIRAGE**

LOOK AHEAD

A Heuristics Driven Paradigm

Candidate Messages

Now on Netflix
Season 3

Continue Watching for Mom
Pick up where you left off

Top 10
United States
As of 7/31/2020

Top Picks for You

Decision Engine

Email

Push Notifications

More

In-App Alerts

Heuristics based:
- If a user watched Stranger Things Season 1, then send a message about Season 2 arrival
- Do not send if a user has had a similar recommendation in the past x days
- ….

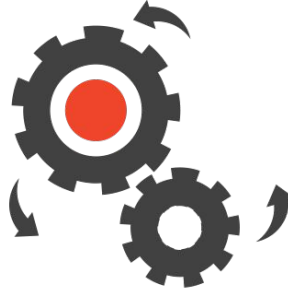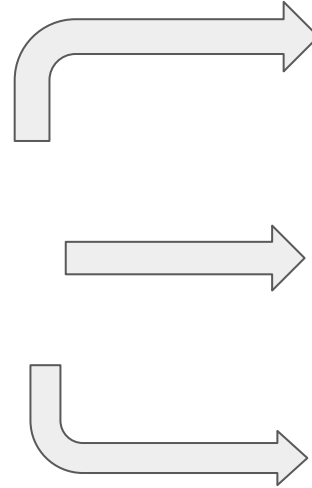# A Heuristics Driven Paradigm

Candidate Messages

ML-Driven
Decision Engine

How many to send?
What to send?

Email

Push Notifications

In-App Alerts

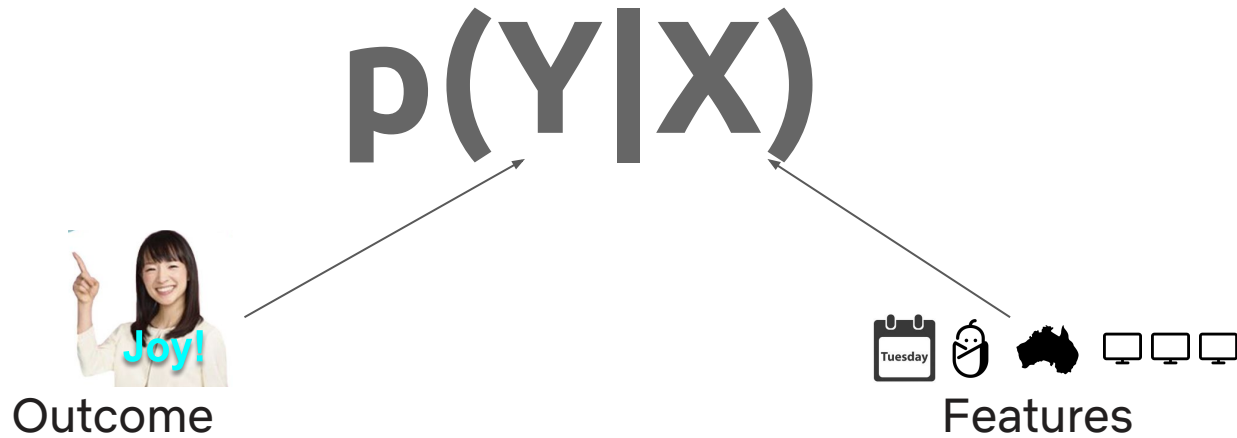# Key Considerations for the System

- Making a personalized, timely decision for every Netflix subscriber

- Removing bias from the system

- Maximizing causal impact

- Balancing reward against cost

Personalizing the messaging decision

A Personalized Messaging Decision

$$p(Y|X)$$

Outcome — Joy!

Features

Can be estimated using a variety of classification (or regression) techniques -

Linear (or Logistic)Regression, GBDT, Neural Network...etc
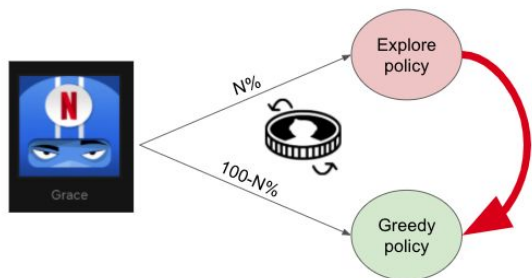
But...

How to obtain data with the full range of messaging frequency and message type variations?
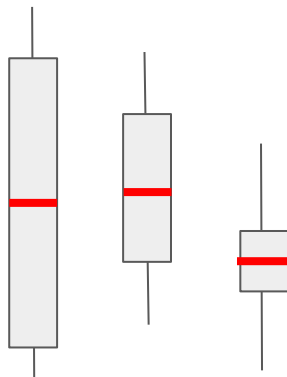
Removing Bias from the System

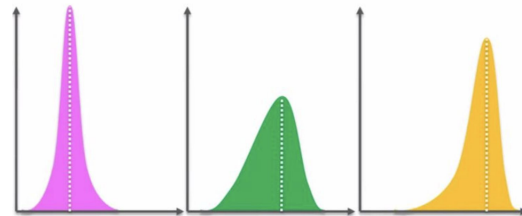# The Obvious Candidate: Explore/Exploit

ε-greedy

- Explore with probability ε
- Otherwise, choose arm with best action

UCB

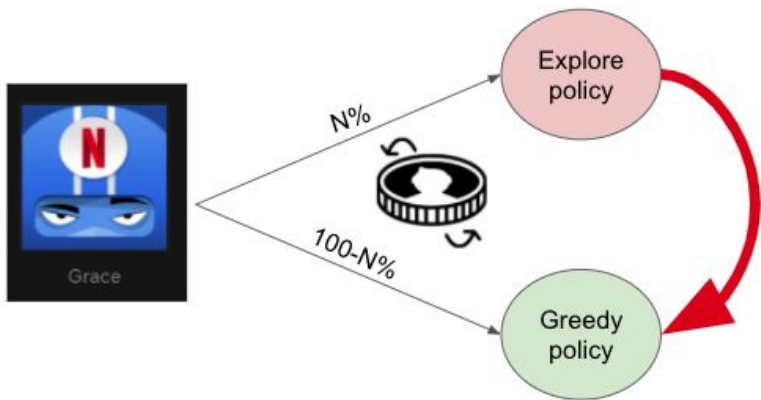

- Pull arm with the highest upper confidence bound

Thompson Sampling

chart source

- Take a random sample from each arm's PDF
- Choose the arm with the highest sampled value.

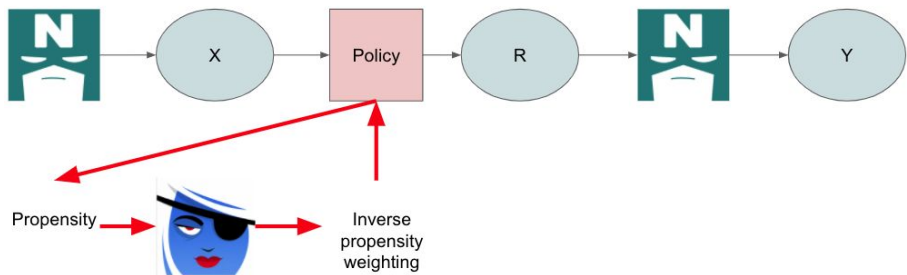# An Example Approach: Personalized Messaging using Contextual Bandit

Other Examples of Debiasing Techniques: Propensity Correction
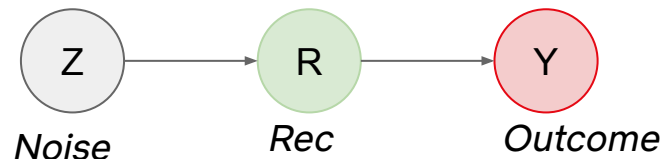
- Propensity Correction (e.g. IPS)

- Instrument Variables..

But...

Did a subscriber visit Netflix and watch a movie because the message we sent was truly relevant and helpful?
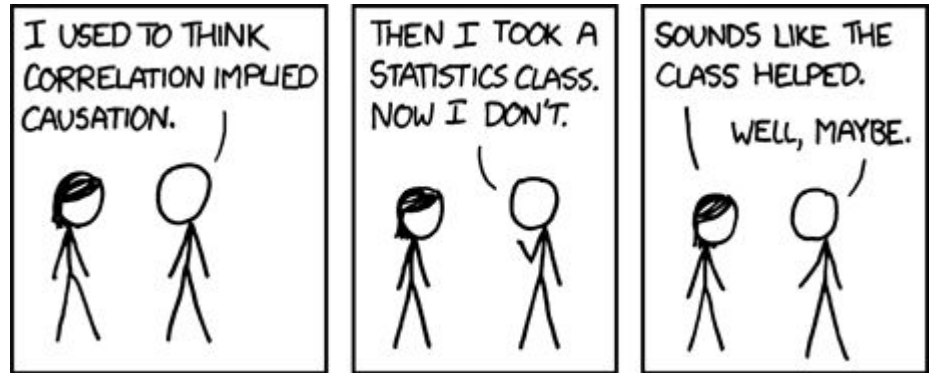
Would they have watched a show even if we did not reach out?

Maximizing Causal Impact

3

A Causal Personalization System

- p(Y|X) only captures correlation

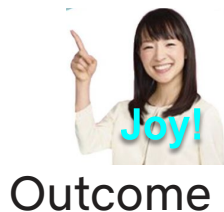- Every observation is influenced by past actions from our messaging system

Recall that we built a *Correlational* Personalization Model for Messaging…

$$p(Y|X)$$

Outcome

Features

Explicitly Model Past Actions

$$p(Y|X, do(R))$$

Personalized Decision Making

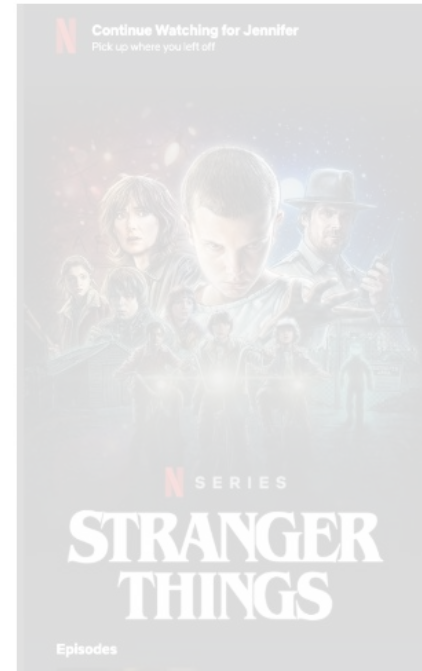R ∈ {∅, [**Top Picks for You**], [**Continue Watching for Mom** Pick up where **Now on Netflix** Season 3], ...}

Send a Message when...

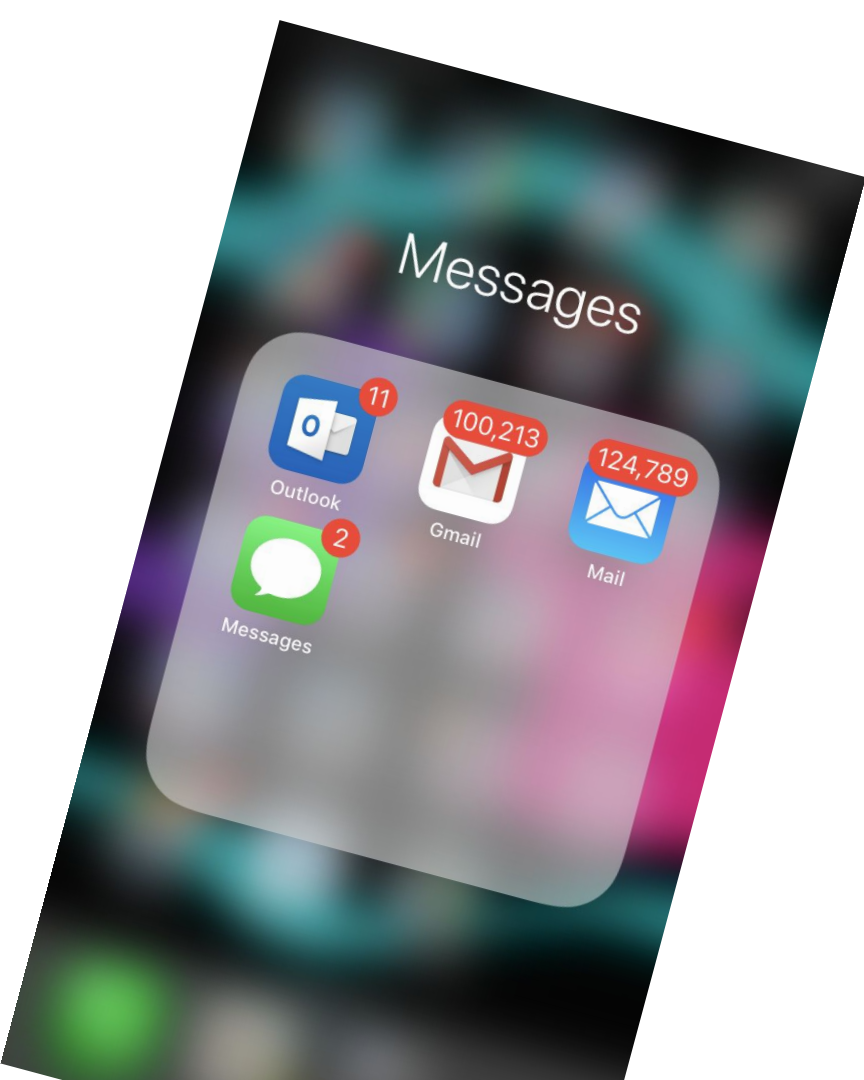Member satisfaction with message

$$p(Y|X, do([\text{🖼}]))$$

Member satisfaction with no message

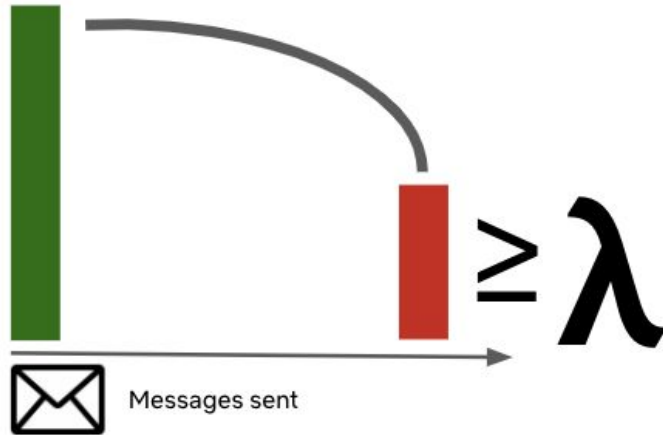$$p(Y|X, do(\varnothing))$$

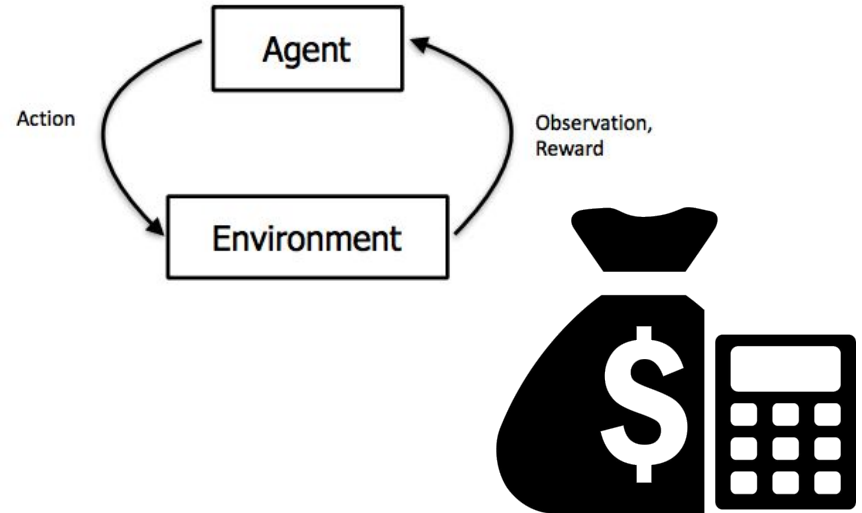# Balancing Reward against Cost

4

More ≠ Better

How to impose a volume constraint?

How to Impose a Volume Constraint?

- A simple approach:
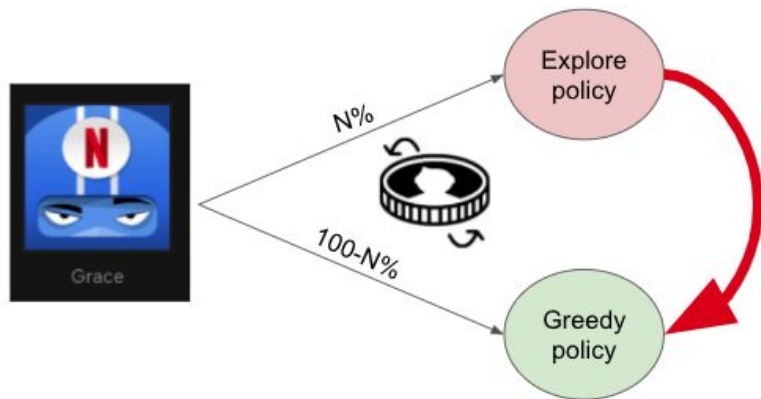 Set an Incrementality Threshold

- Other flavors of
  Reinforcement Learning

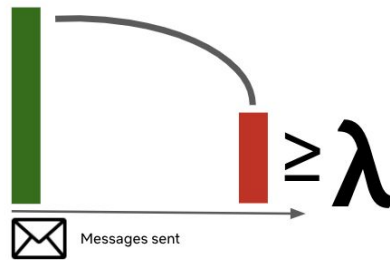# An example of how to put this together.... A Causal Bandit

- Randomly sample from frequency and candidate message distributions

Explore policy

N%

100-N%

Grace

Greedy policy

- Estimate incrementality of a message
- Greedily assemble the set of messages to send, subject to an incrementality threshold
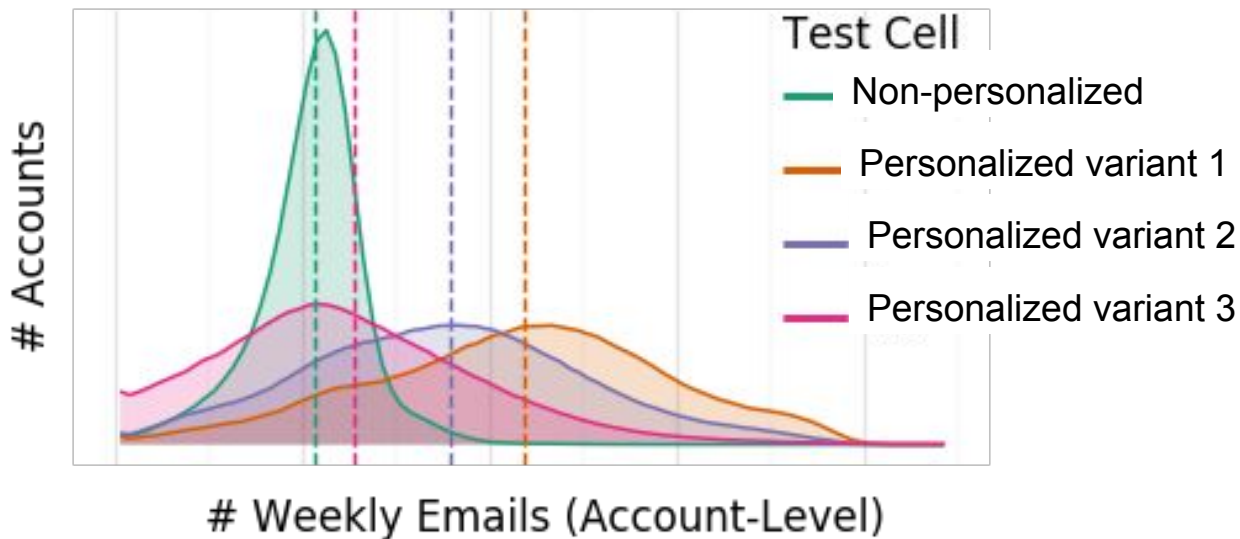
$\geq \lambda$

Messages sent

Offline Evaluation
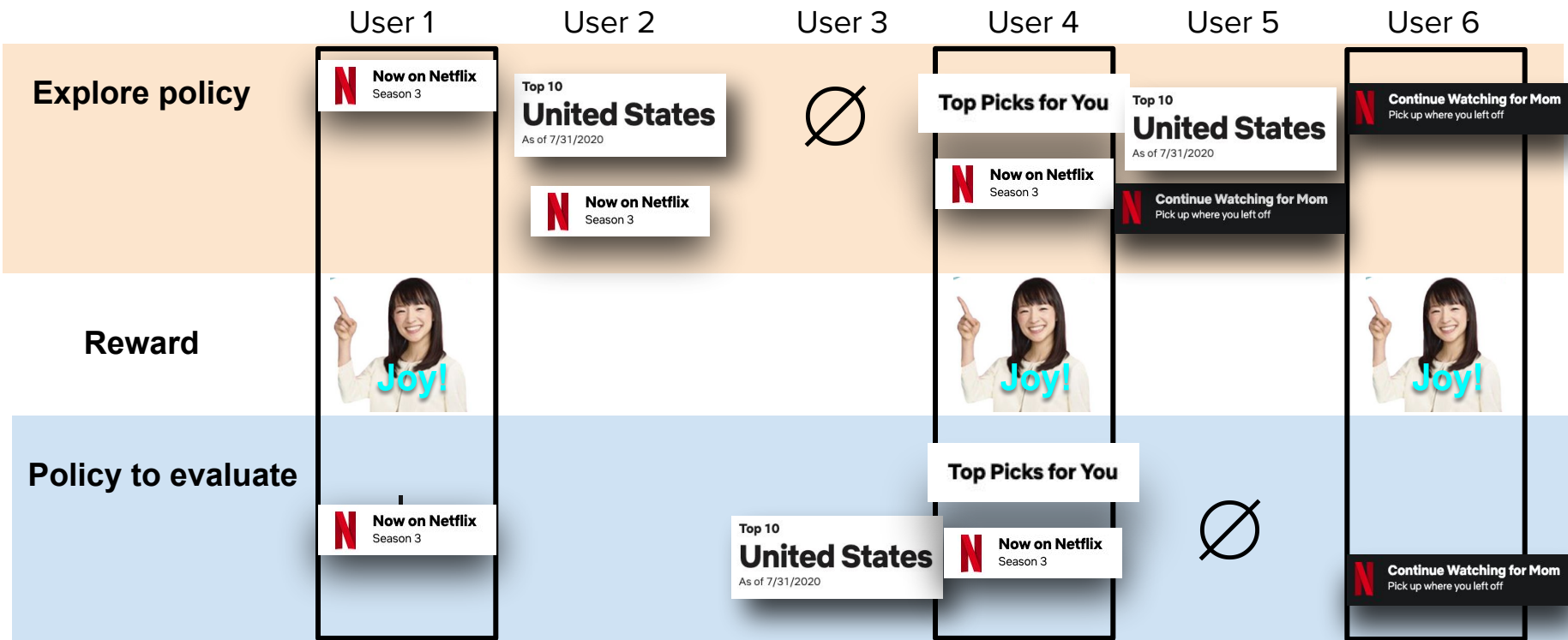
Simulate online metrics offline!

Evaluating Online

- An A/B test still allows us to evaluate the long term behavior of a given policy

Recap

- Making a personalized, timely decision for every Netflix subscriber

- Removing bias from the system

- Maximizing causal impact

- Balancing reward against cost

- Lots of exciting future work…..

Check out more in [Recap: Designing a more Efficient Estimator for Off-policy Evaluation in Bandits with Large Action Spaces](#)

Thank You.

Grace Huang

ghuang@netflix.com