

A man wearing a light-colored cowboy hat and a red long-sleeved shirt is riding a brown horse. The background shows a desert landscape with a prominent mesa under a clear blue sky. The text "DECISION MAKING AND THE BANDIT PROBLEM" is overlaid on the image. "DECISION MAKING" and "BANDIT" are in bright green, while "AND" and "PROBLEM" are in white. "AND" has a white underline.

DECISION MAKING AND
THE BANDIT PROBLEM

A man wearing a light-colored cowboy hat and a red long-sleeved shirt is riding a dark horse. The background is a desert landscape with a prominent, flat-topped rock formation under a clear blue sky. The text is overlaid on the image.

Starring **Noel Welsh**

A **mynna** Production

In Conjunction With
_.underscore

Showing at

Strata London 2013

A man wearing a light-colored cowboy hat and a red long-sleeved shirt is riding a dark horse. The background is a desert landscape with a prominent rock formation under a clear blue sky.

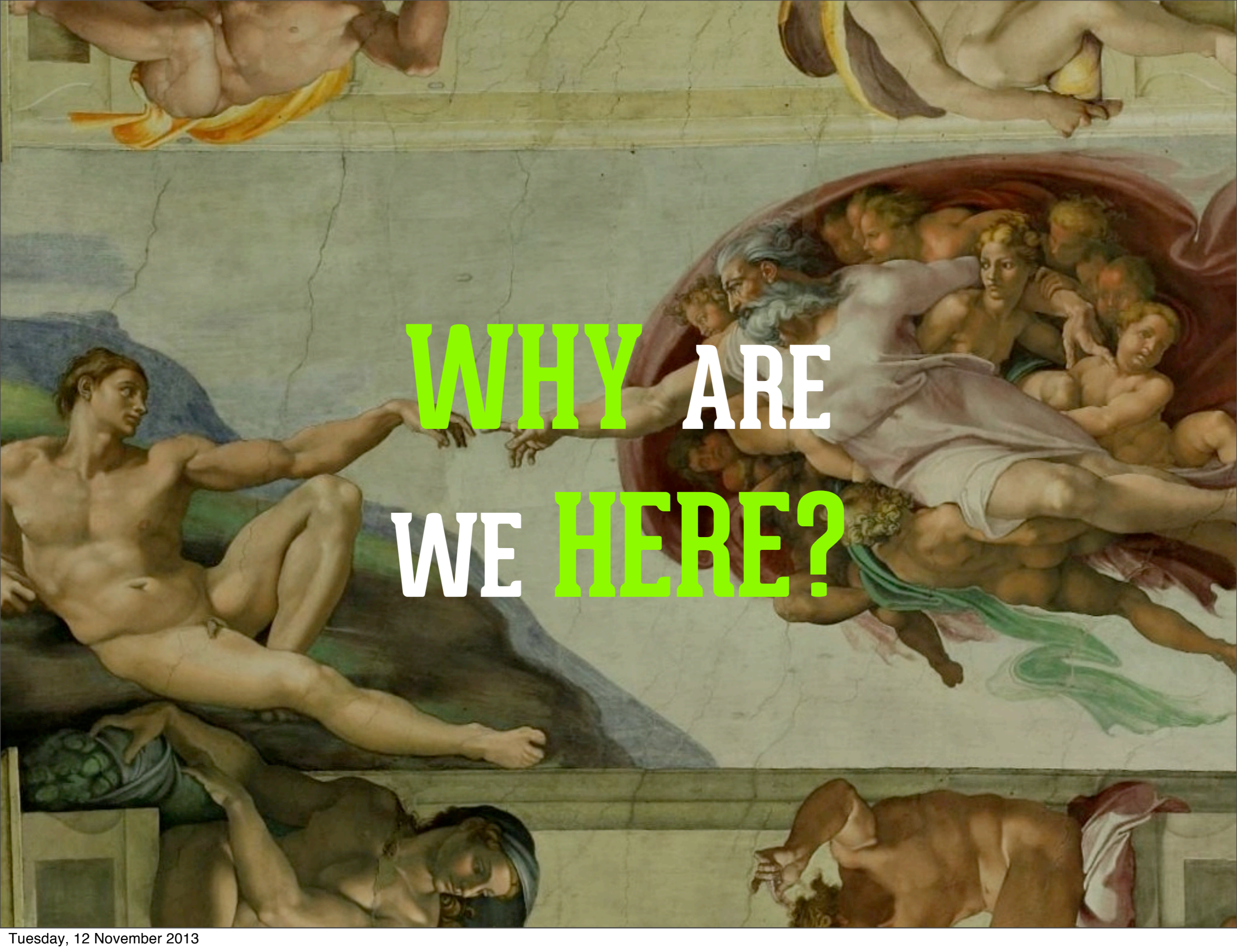
Starring **Noel Welsh**

A **mynna** Production

In Conjunction With
_.underscore

Showing at

Strata London 2013



WHY ARE
WE HERE?

BANDIT ALGORITHMS

[AN OVERVIEW]

TAKE ACTION

AUTOMATICALLY

SELECT ADS

RECOMMEND NEWS STORIES

CHOOSE BETWEEN ALGORITHMS

ETC.

#1

**Maximise reward over
time**

#2

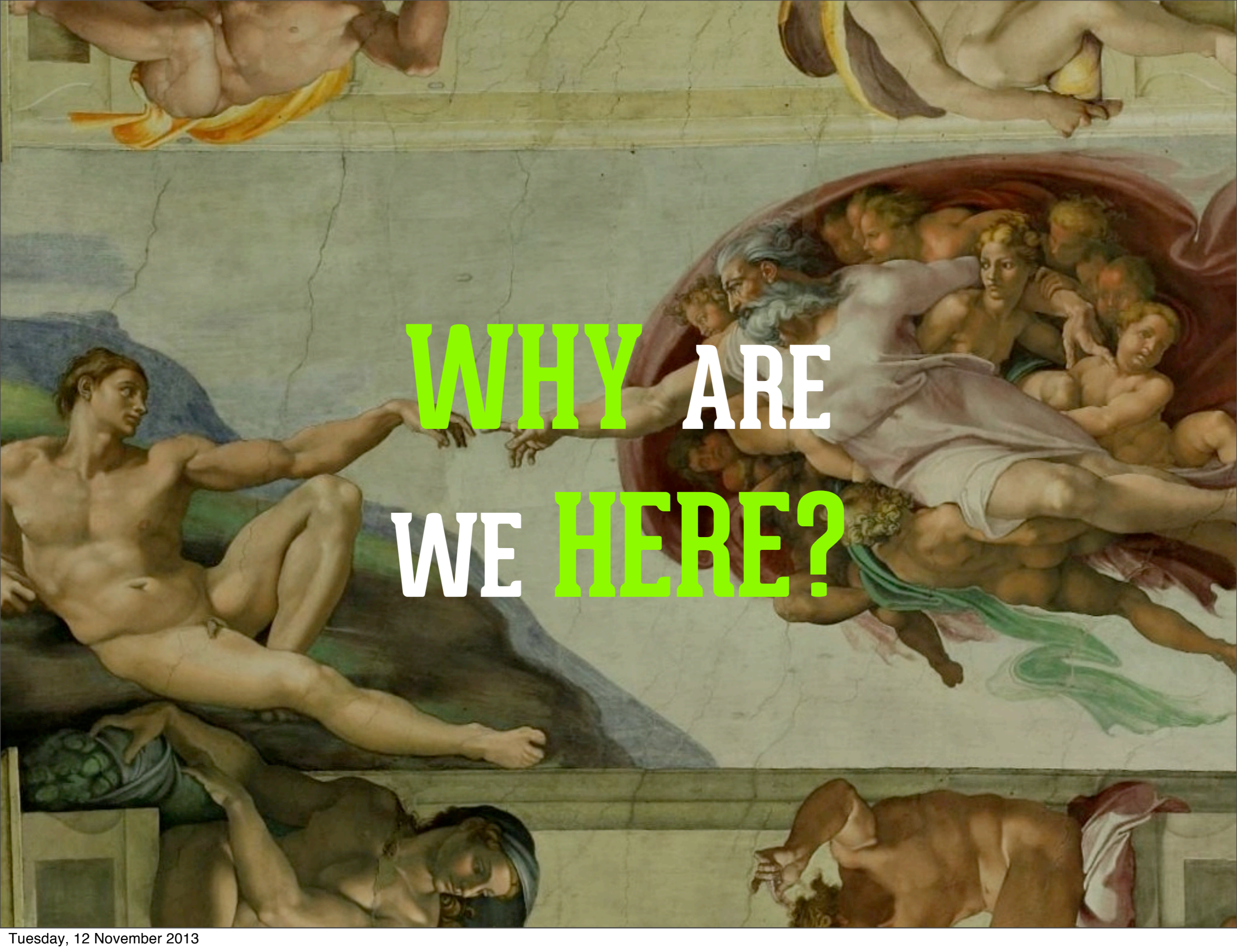
Best arm identification

#3

**Personalisation
[Use structure in the
problem]**

#4

**Brief overview of other
areas**



WHY ARE
WE HERE?

WHAT DO
DATA SCIENTISTS
DO?

Metric
(sign-ups, revenue, etc)

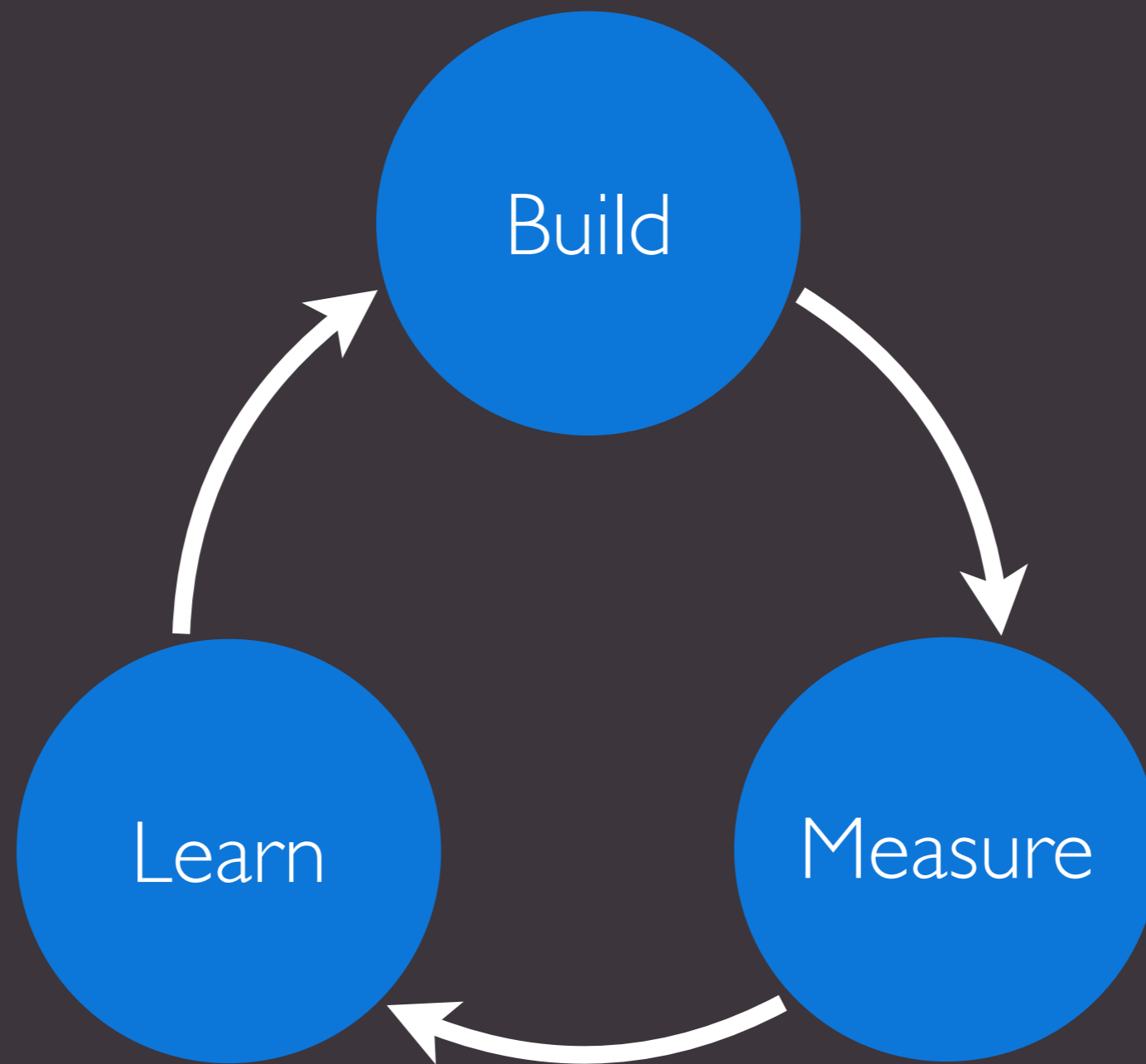


Make this happen



HOW?

EFFECTIVE ACTION





FASTER IS BETTER



THE BANDIT PROBLEM

[EST 1952 ... OR 1933]

Monique Myna's Typewriter Travels



The picture above is of a beautiful 1940s black and gold Royal typewriter.

It's in need of a little restoration but it's still able to get out and about!

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For more typewriter news
Join our mailing list

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k arms (or variants)

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Select a variant

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Receive a reward

REPEAT

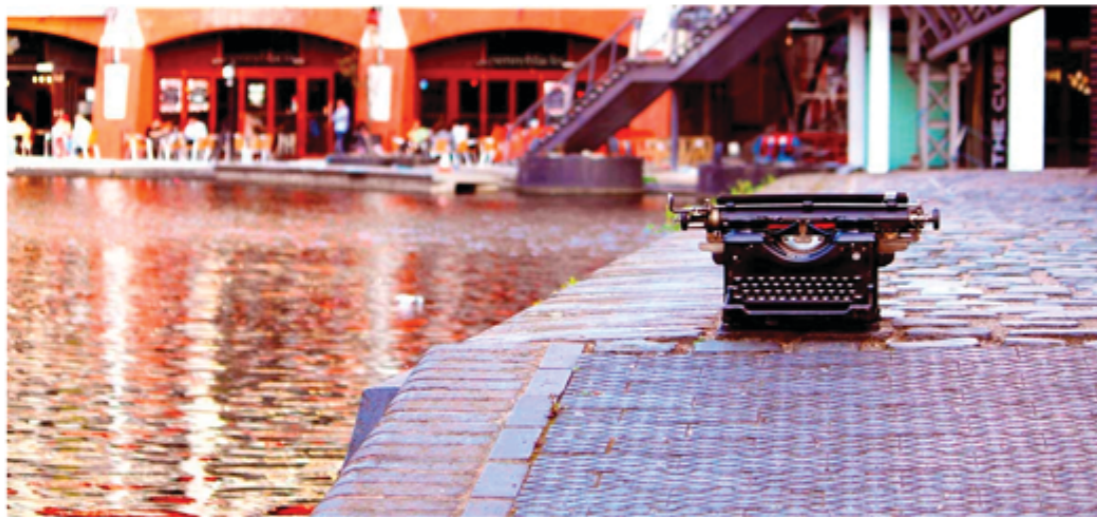
**MAXIMISE TOTAL
REWARD**

HOW?

**DISPLAY VARIANT WITH
HIGHEST AVERAGE
REWARD**

Good Variant

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Bad Variant

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Views: 1
Reward: 0
Average: 0

Good Variant

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Bad Variant

Monique Myna's Typewriter Travels

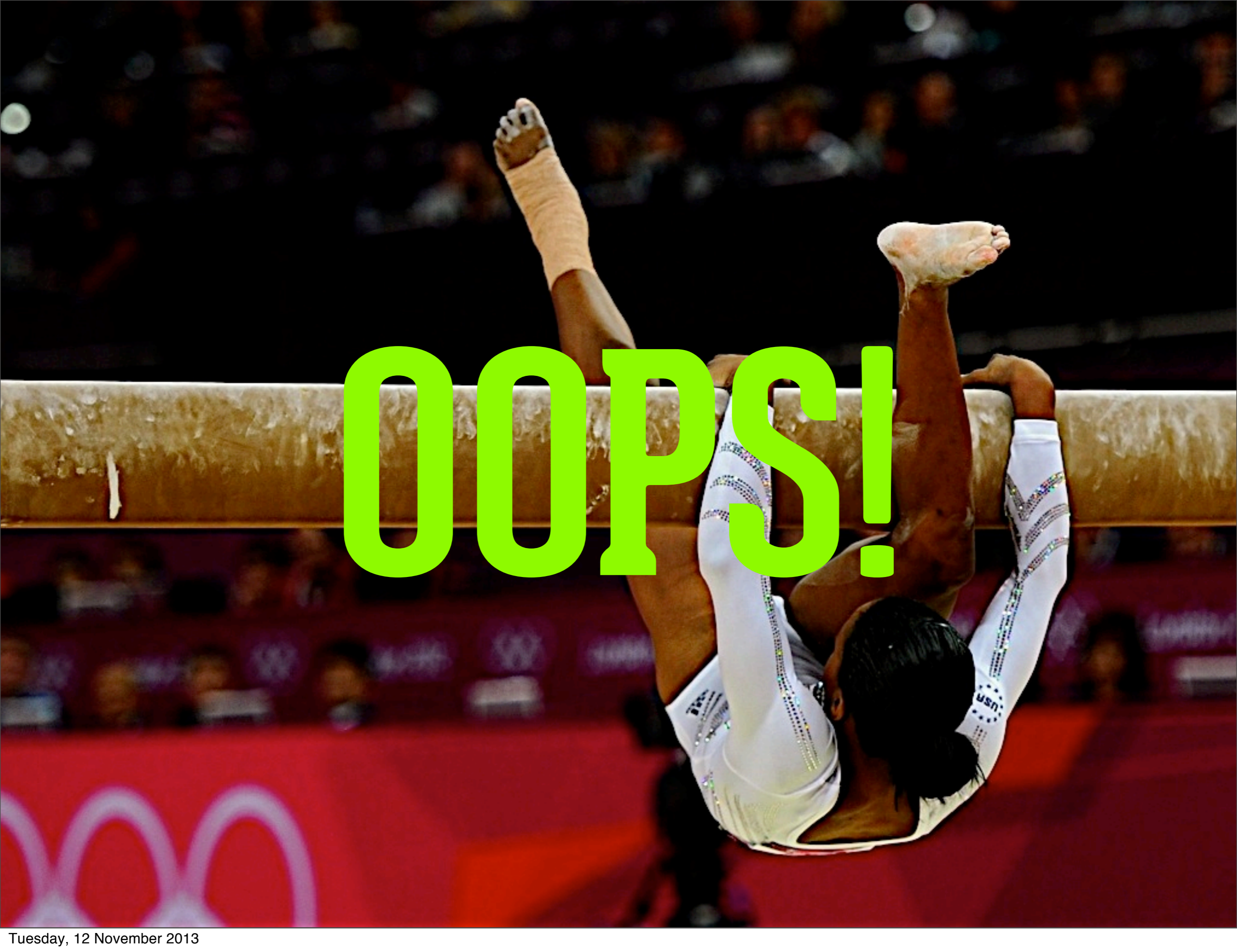


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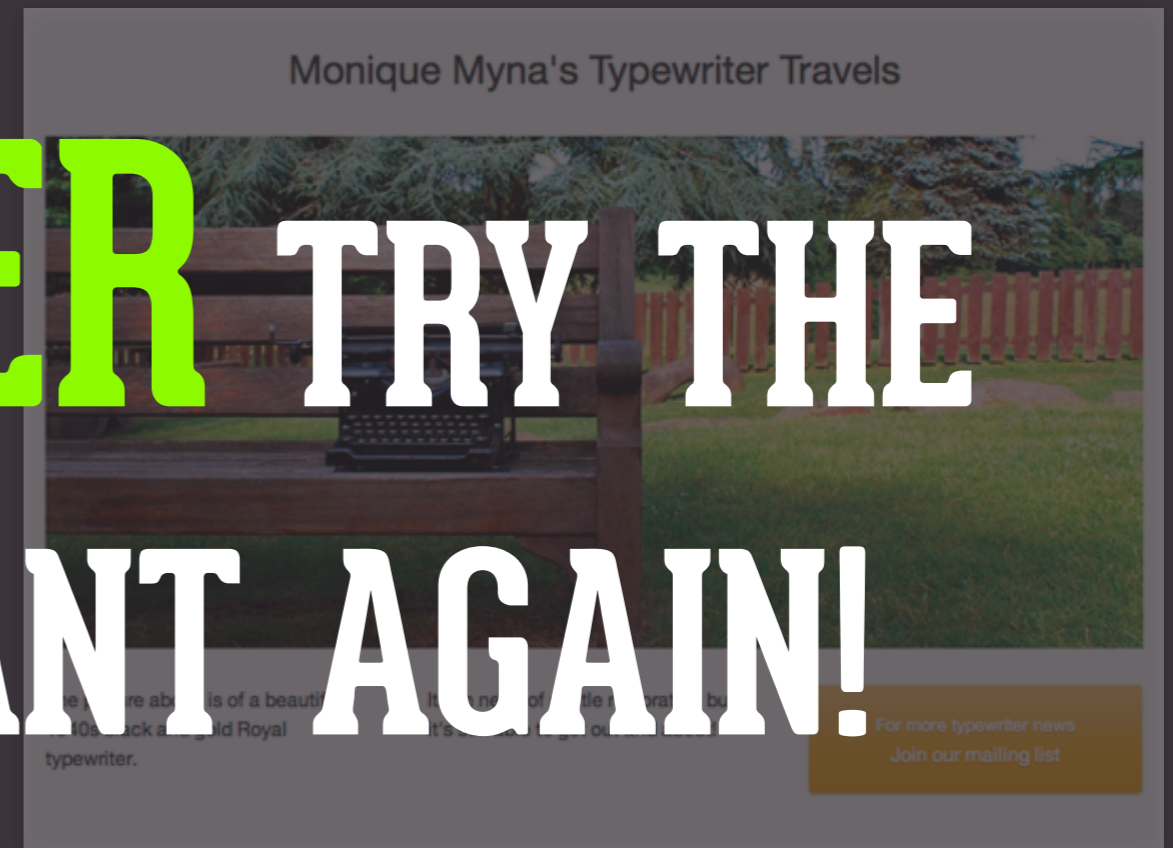
Views: 1
Reward: 1
Average: 1



OOPS!

Good Variant

Bad Variant



Views: 1
Reward: 0
Average: 0

Views: 1
Reward: 1
Average: 1

BALANCE EXPLOIT
AND EXPLORE

EXPLOIT

**TRY THE VARIANT THAT
HAS WORKED BEST IN
THE PAST**

EXPLORE

TRY OTHER VARIANTS
TO SEE IF THEY'RE
BETTER

E-GREEDY

10% EXPLORE

90% EXPLOIT

Don't like 10% and 90%? Change it.

THOMPSON SAMPLING

BAYESIAN APPROACH

USING

PROBABILITY

MATCHING

**Select arm in proportion
to probability it will
receive the highest
reward**

$$P(\text{arm}_i) \propto P(r_i > r_1, \dots, r_j)$$

r_i is the reward of arm_i

**Binary reward: Beta
Prior**

**Gnarly integration:
Monte Carlo**

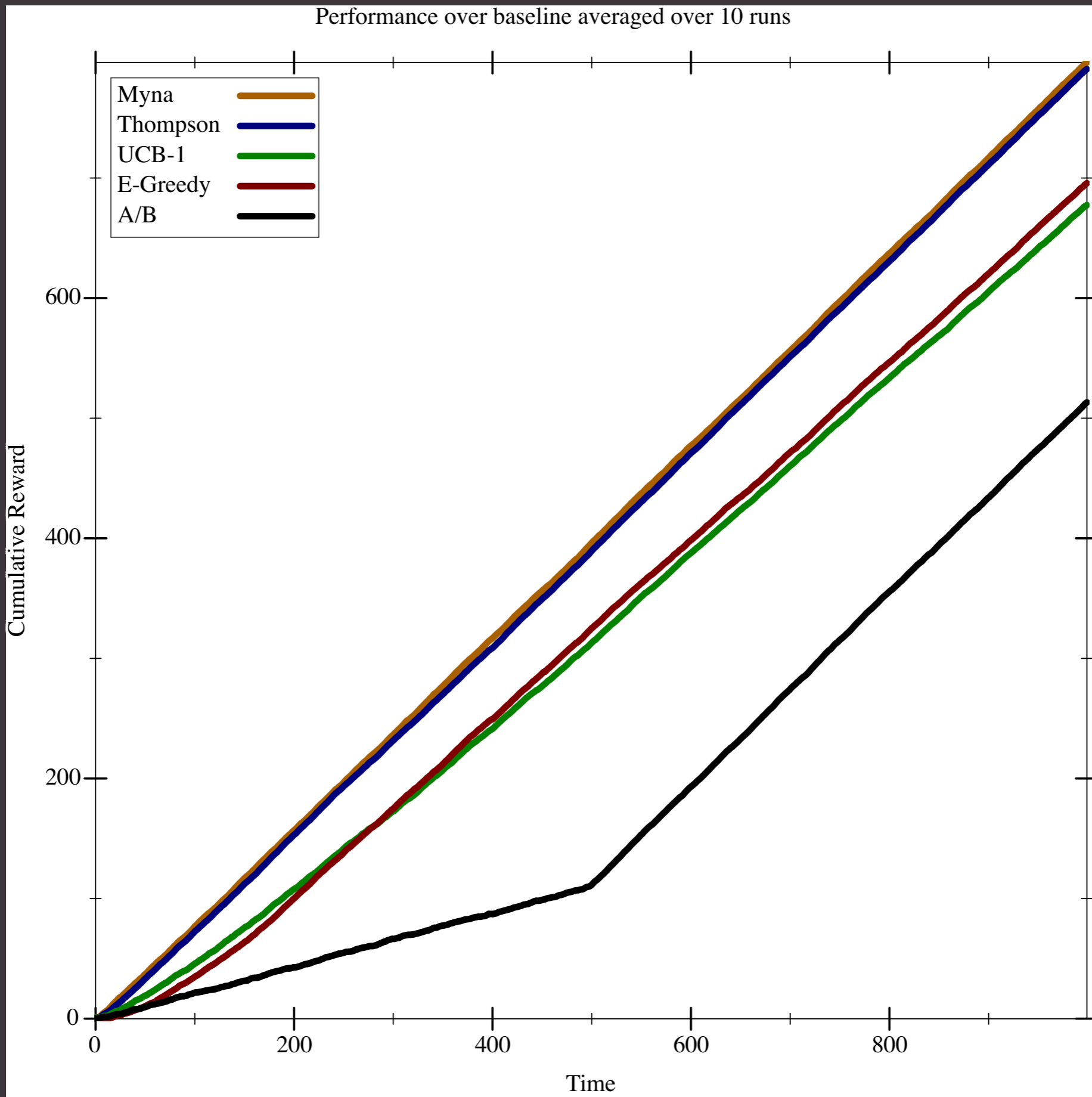
THOMPSON SAMPLING

$$\forall i, p_i \sim \text{Beta}(\theta_i)$$

choose arm_i with $p_i > p_j, \forall j \neq i$

**ONE SAMPLE IS
ENOUGH!**

**OTHER
ALGORITHMS E.G.
UCB-1, KL-UCB**



IN PRACTICE

THOMPSON SAMPLING IS

SUPERIOR

THEORY

**MINIMISE EXPECTED
REGRET**

$$\text{Regret}(T) = \mu^* T - \mathbb{E} \left[\sum_{i=1}^T r^i \right]$$

μ^* : expected reward of best arm

r^i : reward at time i

$$\textit{Regret}(T) = \Omega(\log(T))$$

THOMPSON SAMPLING IS **OPTIMAL**

[Kaufmann, Korda, & Munos, 2012;
Agrawal and Goyal, 2012]

BEST ARM IDENTIFICATION

FIND WITH **HIGH**
PROBABILITY
ARM(S) WITH HIGHEST
EXPECTED REWARD

A/B TESTING

**BETTER CONFIDENCE
INTERVALS**

MIND THE GAP

ADDING STRUCTURE

EXAMPLE:
EACH USER HAS A
PROFILE

**IN GENERAL,
RECEIVE A
CONTEXT VECTOR
AT EACH DECISION**

**ASSUME REWARD IS
LINEAR FUNCTION
OF CONTEXT**

$c_i \in \mathbb{R}^d$: context at time i

$\bar{\mu} \in \mathbb{R}^d$: linear payoff function

$c_i^T \bar{\mu}$: expected payoff

DO SAME
PROBABILITY
MATCHING
AS BEFORE

**Put prior on payoff
function. E.g. Gaussian**

**Create likelihood function
over rewards. E.g. Gaussian**

$$\textit{Regret}(T) = \Omega\left(d\sqrt{(T)}\right)$$

[Agrawal & Goyal, 2013]

ESSENTIALLY
BING'S CTR PREDICTION
ALGORITHM
[Graepel et al, 2010]

OTHER BITS AND PIECES

NON-STATIONARY

REWARDS

ADVERSARIAL

REWARDS SET

ARBITRARILY

$$\textit{Regret}(T) = \Omega\left(\sqrt{T}\right)$$

PREDICTABLE
[BUT NON-STATIONARY]
REWARDS

LOTS MORE

**[COMBINATORIAL BANDITS,
LINEAR OPT etc.]**

A silhouette of a cowboy riding a dinosaur against a sunset sky. The cowboy is wearing a hat and is riding a large dinosaur, possibly a T-Rex, which is shown in profile. The background is a dramatic sky with orange and purple clouds, and a bright sun is visible near the horizon. The text is overlaid on the image.

THANK YOU!
NOW GO FORTH AND
ENGAGE IN
BANDITRY

MORE:

noelwelsh.com &

bandits.mynaweb.

com

CREDITS

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