ODSC-East 2022

Reinforcement Learning for Recommender Systems

From Contextual Bandits to Slate-Q

Christy Bergman, DevAdvocate Ray RLlib
https://linkedin.com/in/christybergman
christy@anyscale.com
@cbergman on Twitter

Avnish Narayan, Software Engineer Ray RLlib
https://linkedin.com/in/avnishn
avnish@anyscale.com
@narayan_avnish on Twitter

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RLlib

Overview of the tutorial

25 min: Intro to RL and why use RL to solve Recommender Systems?

10 min: Break/ Q&A

25 min: RLlib's Contextual Bandits Algorithms Applied To Recommender Systems

10min: Break/ Q&A

10 min: RLlib's SlateQ Applied To Recommender Systems

~1.5h

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What is Reinforcement Learning (RL)?

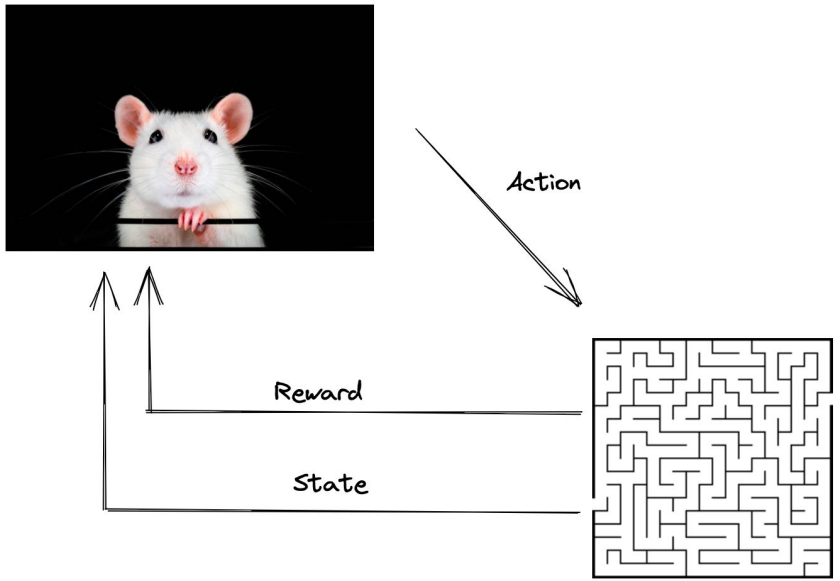
We want to teach a mouse to get to the center of a maze … how can we do that?

Place bits of cheese in the maze along paths that we **do** want the mouse to take.

Place bits of poison along paths that we **don't** want the mouse to take.

Let the mouse repeatedly explore the maze for a fixed time from different random starting points.

Eventually the mouse learns all paths from everywhere in the maze that maximize cheese and minimize poison.



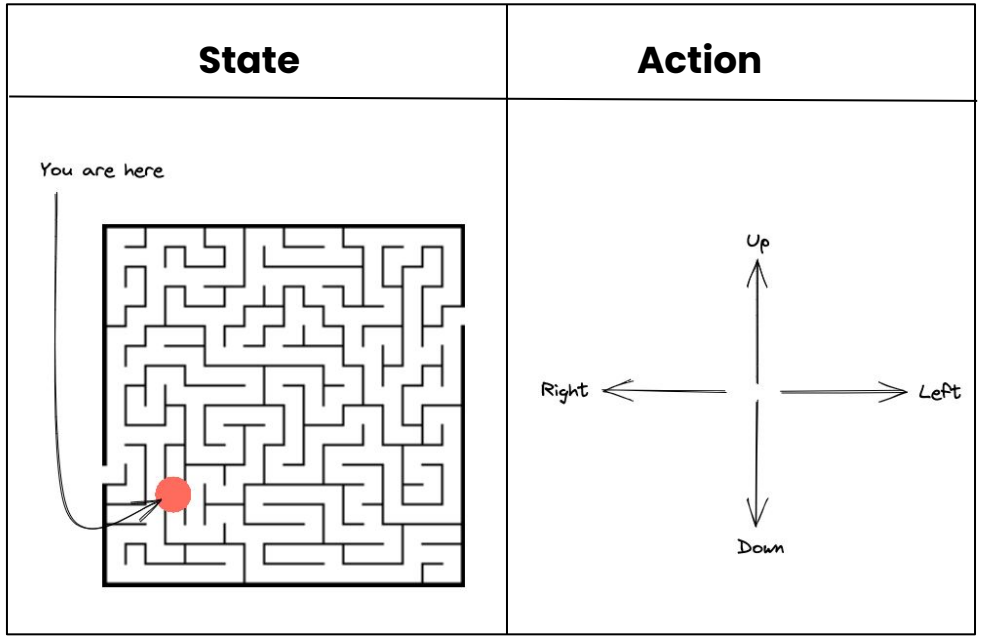
What is Reinforcement Learning (RL)?

The mouse can be at different positions in the maze. We call this its **state** or observation.

The mouse can move up down left and right in the maze. We call this its **actions.**

There are terminal states in which the mouse no longer needs to act, such as if the mouse enters the center of the maze.

For every action that mouse takes at its current state to transition into a new state we call this a **time step.**



What is Reinforcement Learning (RL)?

The mouse gets cheese or poison depending on whether its taking the best action at its state. We call this **reward.**

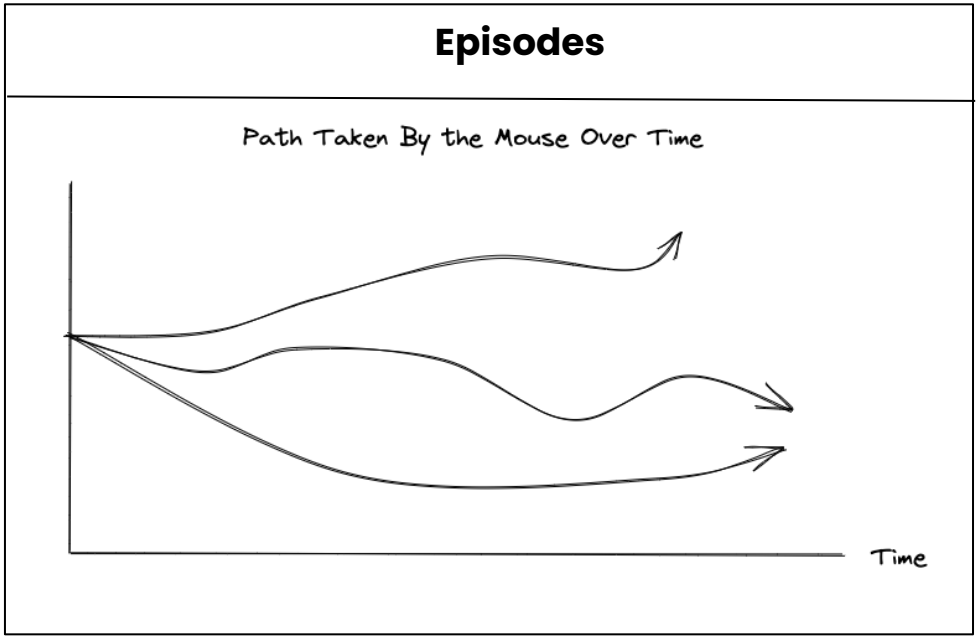
What is Reinforcement Learning (RL)?

Mouse explores follows the cheese trail for some time.

Reset it to a new random state after n time steps.

The sequence of time steps mouse creates from starting state till reset is an **episode.**

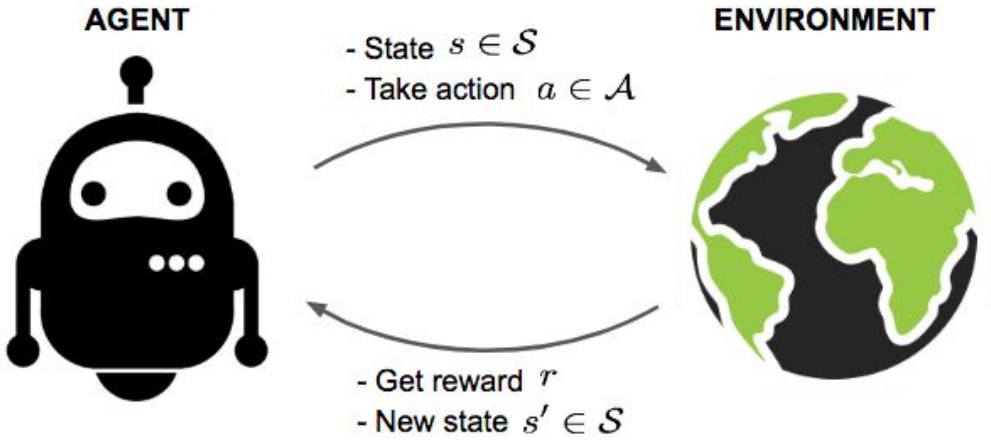
When episode terminates, **done** signal is true.



What is Reinforcement Learning (RL)?

Use **reinforcement learning** to update the mouse's, or our **agent's,** using the episodes the mouse collects.

1. Mouse plans a path to take.
2. Mouse acts optimally, collecting episodes.
3. We update the mouse using it using collected episodes.
4. Go back to step 1.



Can We Use The Framework Of The Toy Problem And Relate It To A Real World Problem?

RL and Self Driving

Autonomous Vehicle vision-based controller

State: camera images, lidar sensor readings

Action: steering, brake, gas

Reward: +1 safe driving, 0 for unsafe driving

Done: trip ends or if an unsafe driving incident occurs.

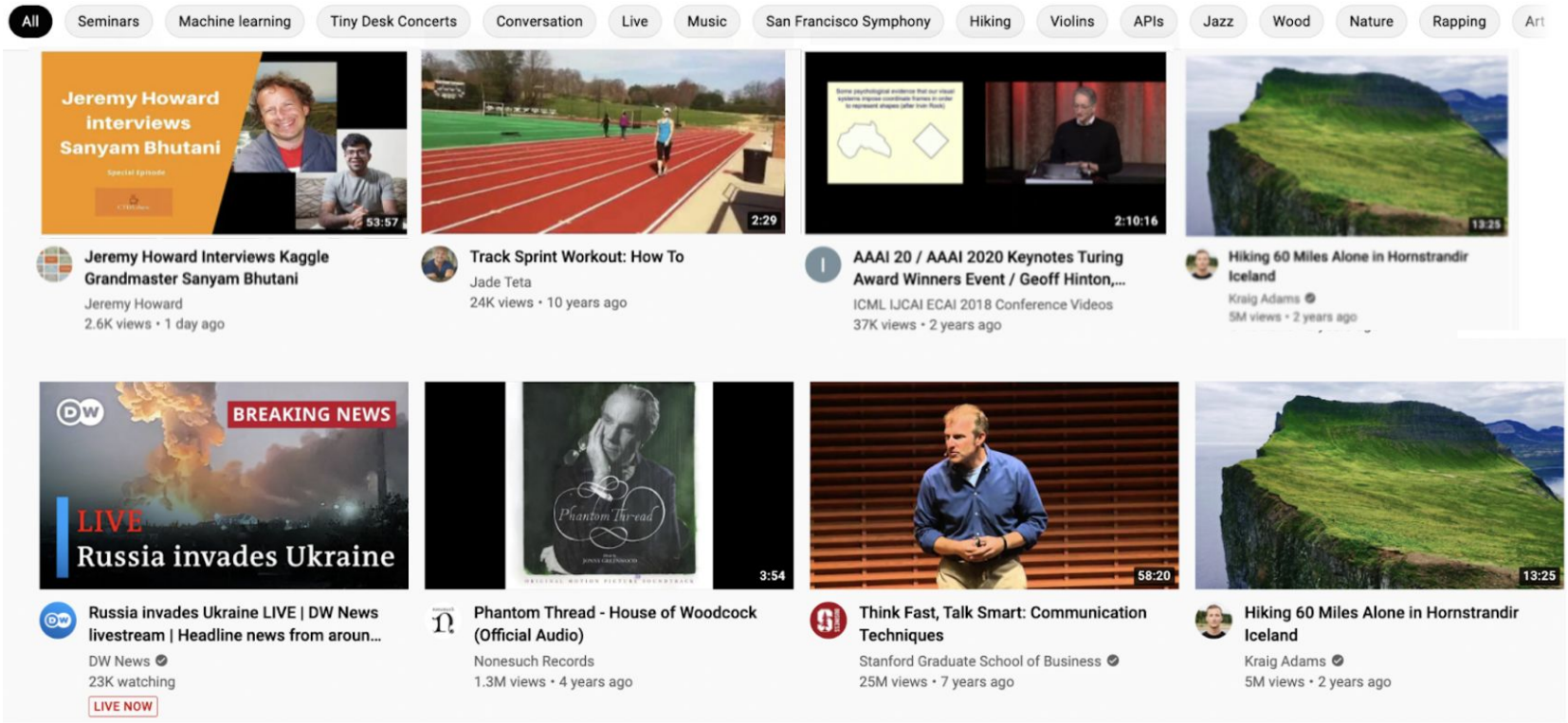
Using RL, train the car-agent to maximize the amount of safe driving behavior during a trip

Recommender Systems and RL

What Are Recommender Systems?

What	Where
Serve up **personalized content**, based on users **interactions**, in order to provide an **improved experience** for each user.	• Games • Rideshare • Purchasing apps (B2B, B2C) • Websites, web apps • Mobile apps • Chatbots • Call centers

RL and Recommender Systems



RL and Recommender Systems

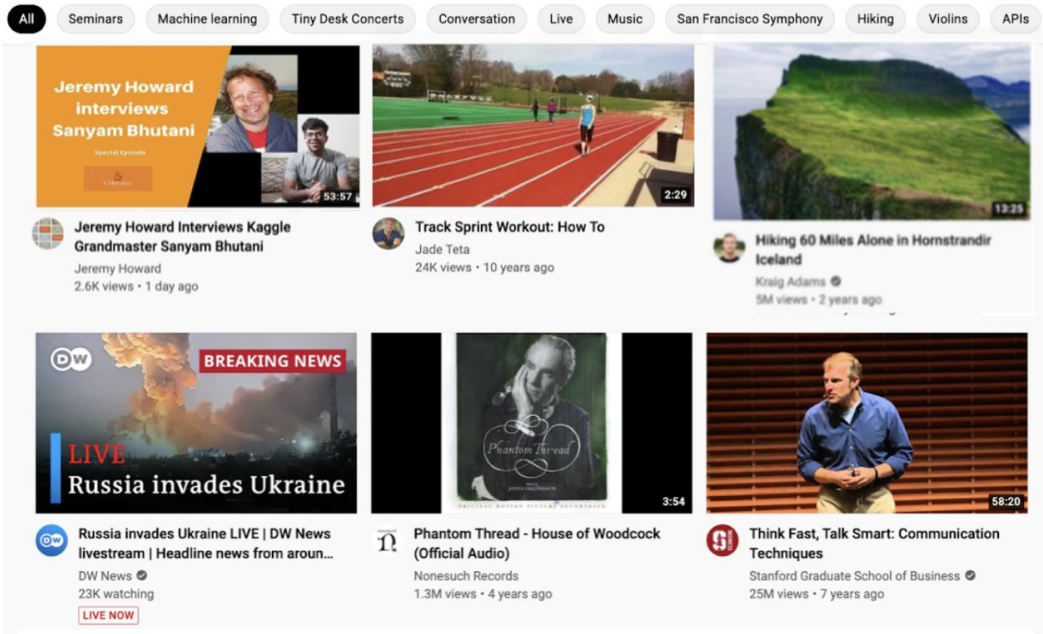
State: user actions, features about the user, user watch history

Action: recommended videos

Reward: +1 if user clicks a piece of content AND long-term satisfaction has increased at the current time step, 0 otherwise

Done: True if we've made the maximum amount of recommendations in a user's session on the website.

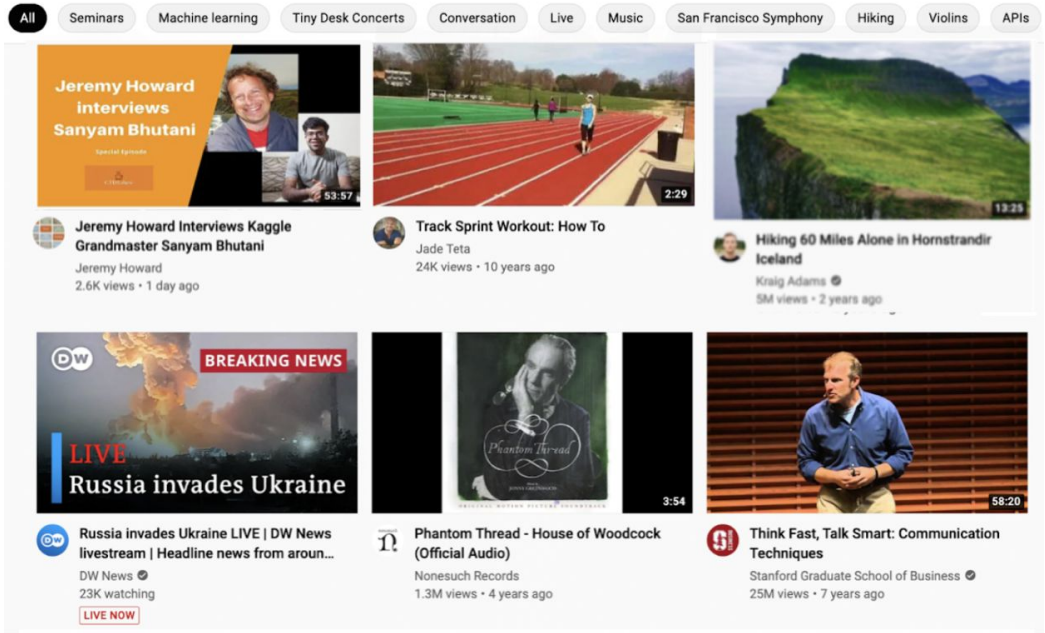
Using RL, train a recsys agent to maximize the click through rate and long term satisfaction of users.



Supervised Learning (SL) Approach to Recommender Systems

High-level steps to build a Recommender System using SL

1) Train a model using supervised learning that takes as input some features about the user (demographic, interests) and outputs some categories or topics the user would be interested in.
2) Use a search ranking algorithm on the categories to produce video recommendations.



Why use RL over SL for Recommendations?

RL Algorithms will train recsys agents that maximize the quality of all the recommendations that are given. SL trains agents to give pointwise recommendations.

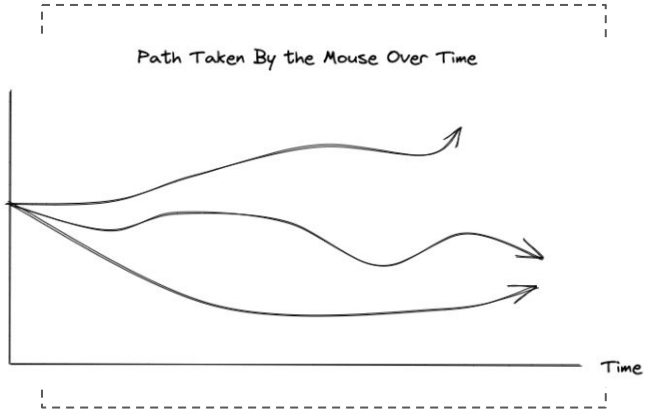
With SL there is no concept of long term satisfaction of a user embedded in to training. This must be hardcoded into the recommender system as a heuristic.

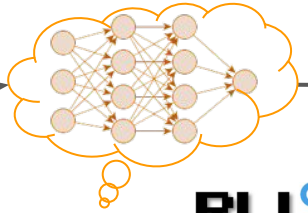
RL can be used to train an end to end recommendation system whereas SL will have brittle hand-engineered features in the system.

Deep RL and RLlib code abstractions

Recommender Systems

Episodes

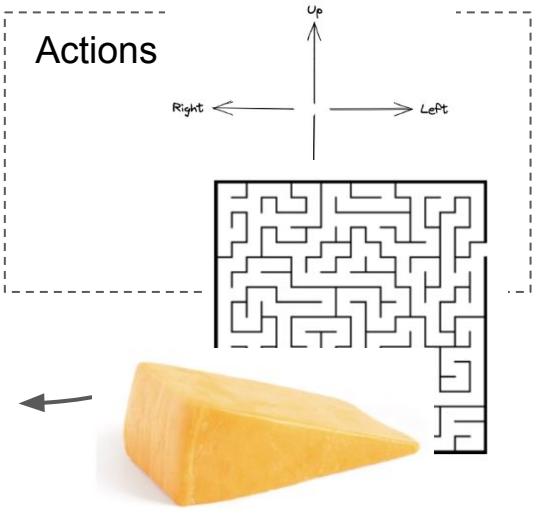




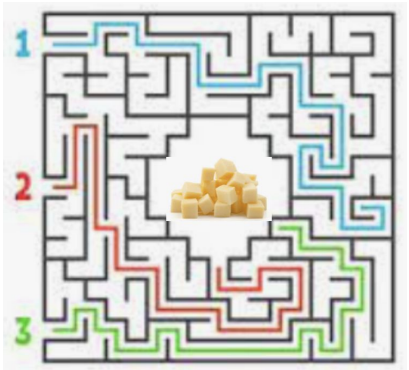
Policy (deep-RL, this is a neural network)

Agent

Actions



State, Rewards



Environment

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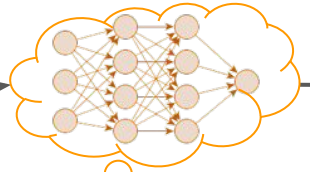
RL Ingredients and RLlib code abstractions

Recommender Systems

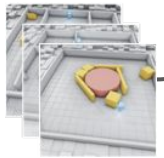
Agent (deep-RL, this is a neural network)



Episodes

Tuple

observation



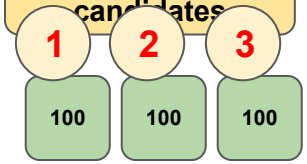
doc: shape=(100, E) dtype=float

user: shape=(E,) dtype=float

(User features, Doc features)

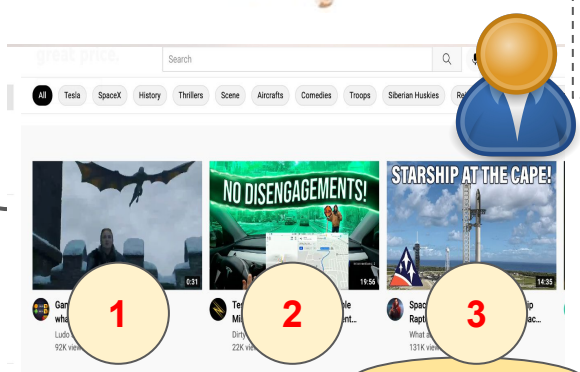
Actions

k-slate out of 100 candidates

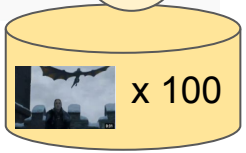


100 x 99 x 98 = ~1M unique slates

State, Rewards



Environment



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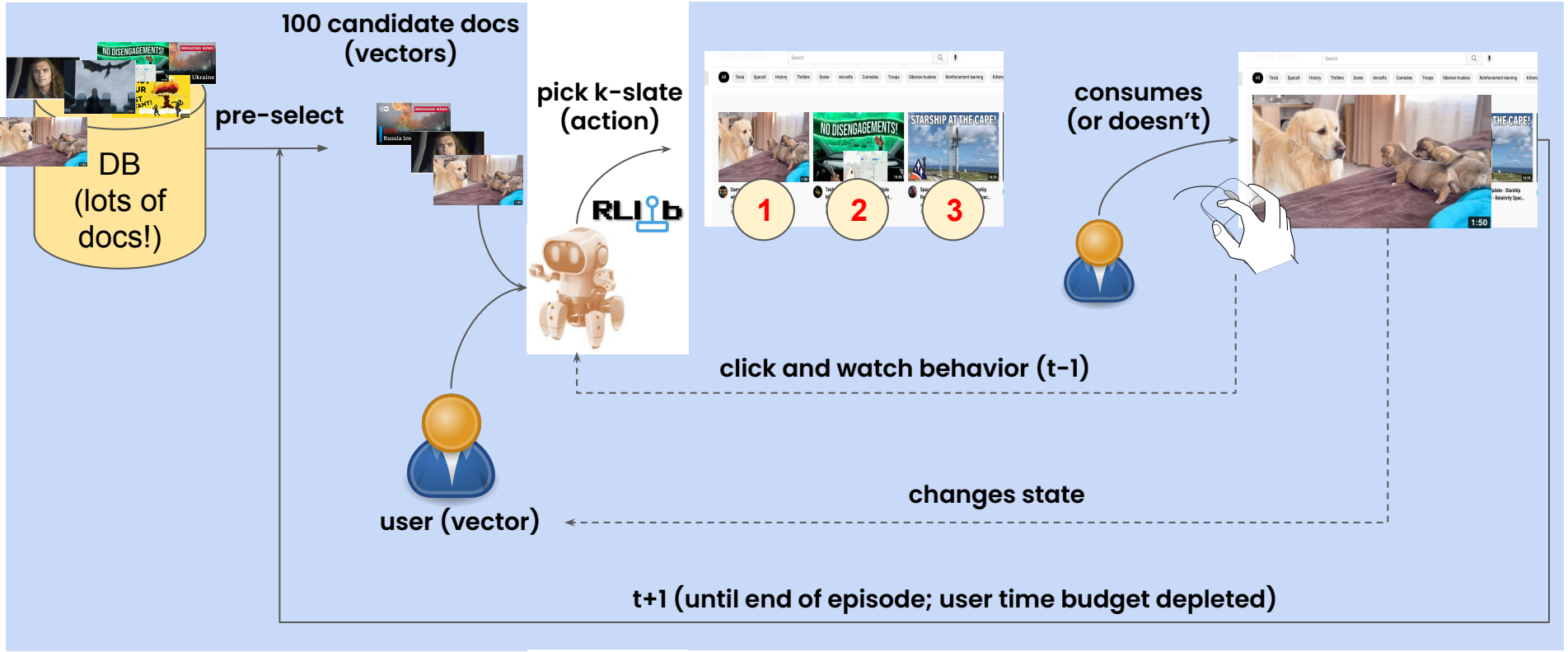
A Recommender System in Action



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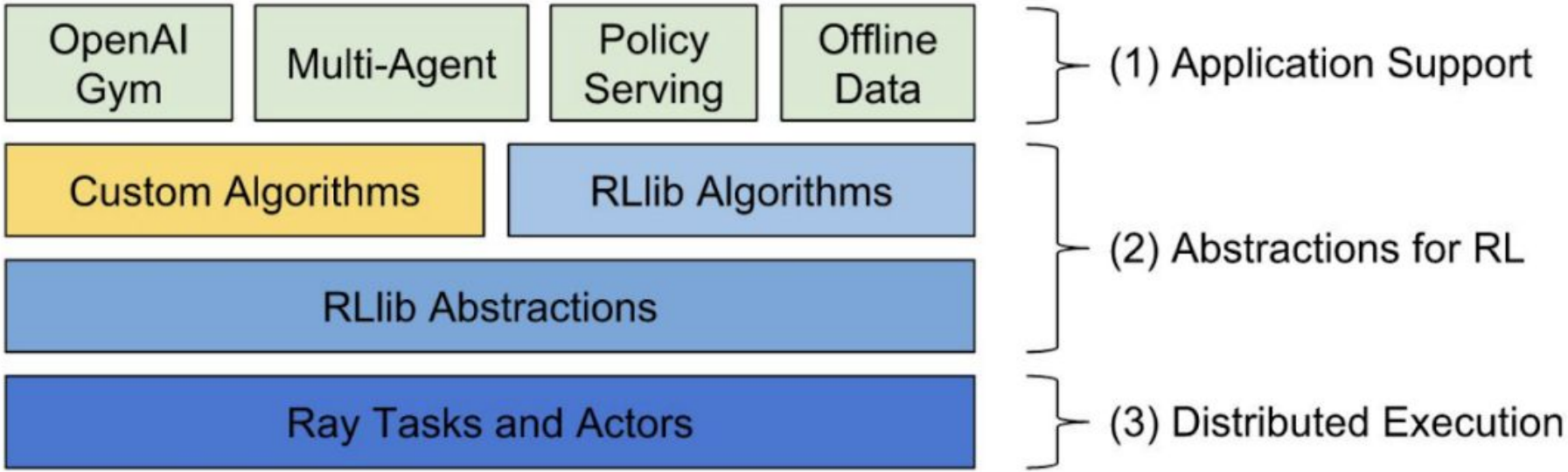
What Software Should I Use To Do RL?

RLlib Parallelize and Distribute at Scale

Ray provides a common framework for distributed RL algorithms using asynchronous parallel Tasks and Actors.



Why Should I Use RLlib

- Support for both TF2 and PyTorch

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- 25+ available algorithms: model-free, model-based, offline RL, meta RL, evolutionary strategies.

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RLlib

Why Should I Use RLlib

- Support for both TF2 and PyTorch
- Almost any algo can learn in a multi-agent setting.
- 25+ available algorithms: model-free, model-based, offline RL, meta RL, evolutionary strategies.
- Benchmarks and tuned examples. Gives you a leg-up, someplace to start with hyperparameter choices.

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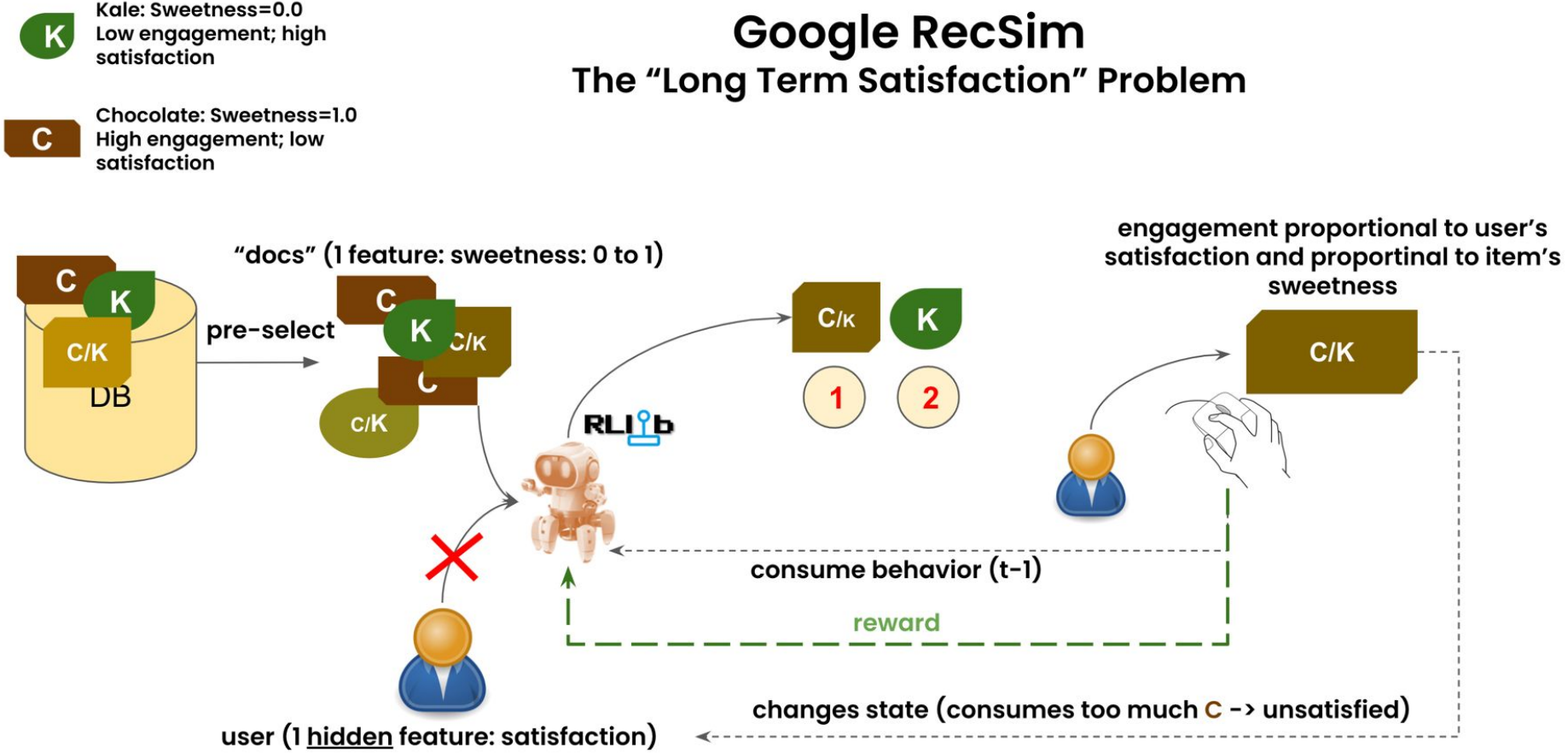
And why should I use RLlib?

Because these companies here do!
Thx for presenting at Ray- and RL Summits!

Google RecSim

The "Long Term Satisfaction" Problem



https://github.com/google-research/recsim

```
$ pip install recsim
```

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10 min Break :)
Then … our Colab Notebook

Google Colab:
https://tinyurl.com/odsc2022rllibtutorial

Github:
bit.ly/odsc_rllib_github

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