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# Learning to Rank with Apache Spark

## A Case Study in Production Machine Learning

#SAISML12

Adam Davidson and Anna Bladzich, Elsevier

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## Empowering Knowledge

Elsevier is a global information analytics business that helps institutions and professionals advance healthcare, open science, and improve performance for the benefit of humanity

ScienceDirect®

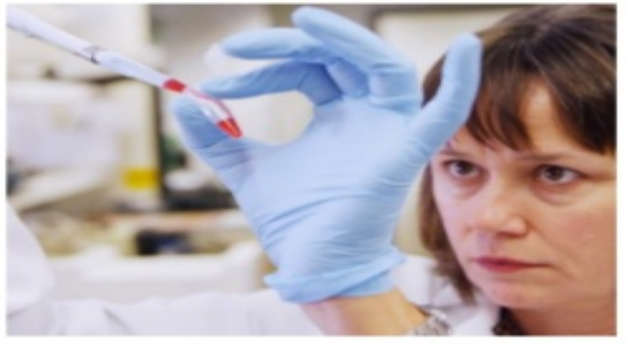
MENDELEY

Scopus®

THE LANCET

# What do we do?

We combine content and data with analytics and technology to help:



RESEARCHERS
to make new discoveries and have more impact on society

CLINICIANS
to treat patients better and save more lives

NURSES
throughout their careers and to help save lives

# Why do we need recommendations?

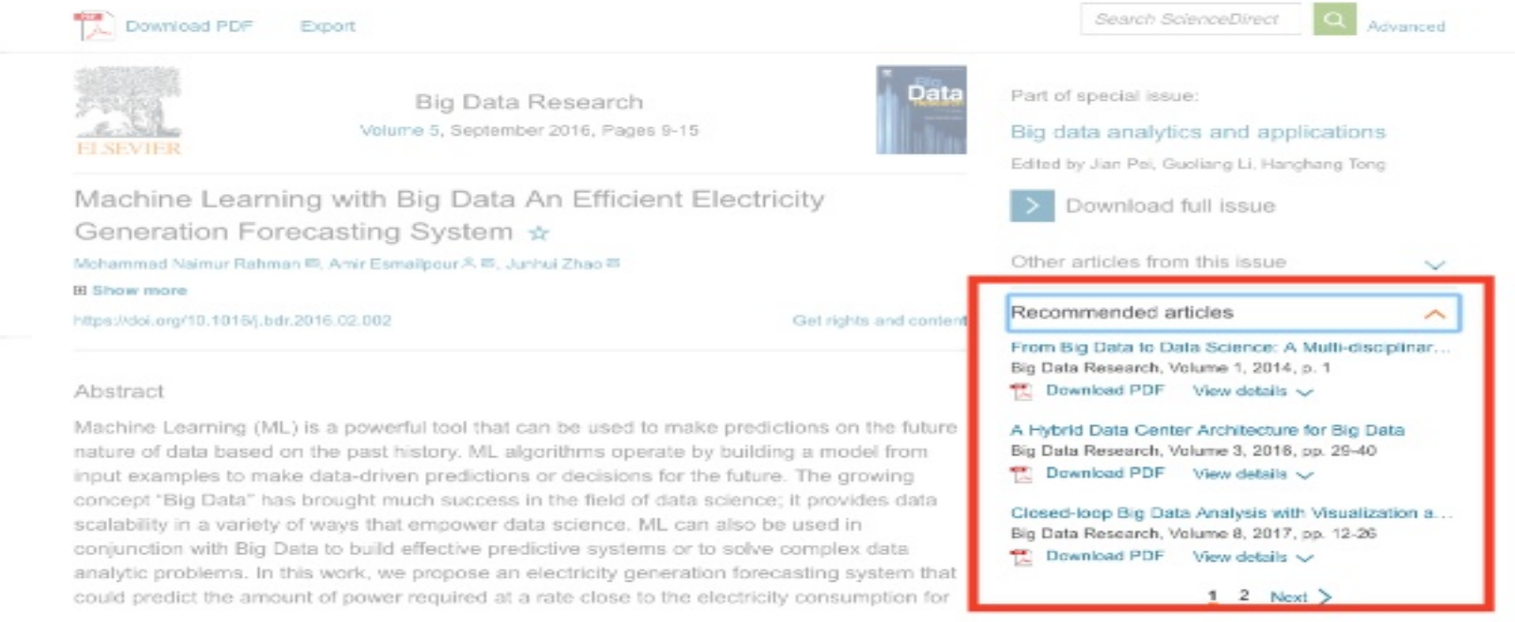
THE $LD_{50}$ OF TOXICITY DATA IS
2 KILOGRAMS PER KILOGRAM.



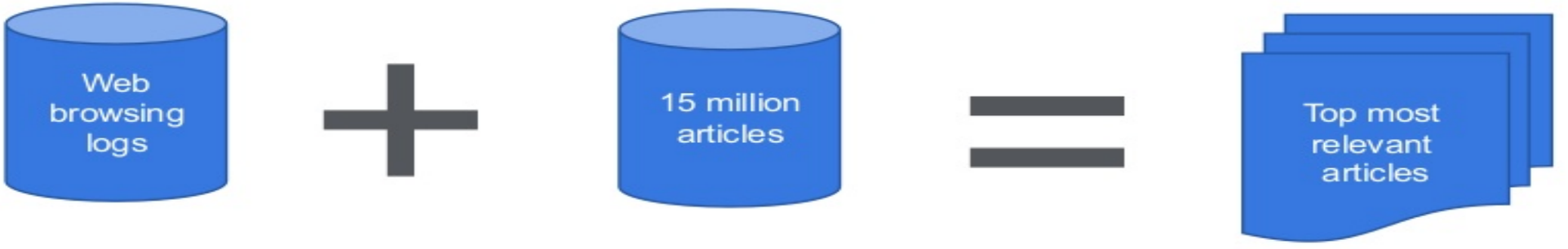
Image: xkcd

# ScienceDirect

- Scientific publication database
- 15 million articles
- Millions of visitors every month



# How did we build recommendations for ScienceDirect?



Collaborative Filtering

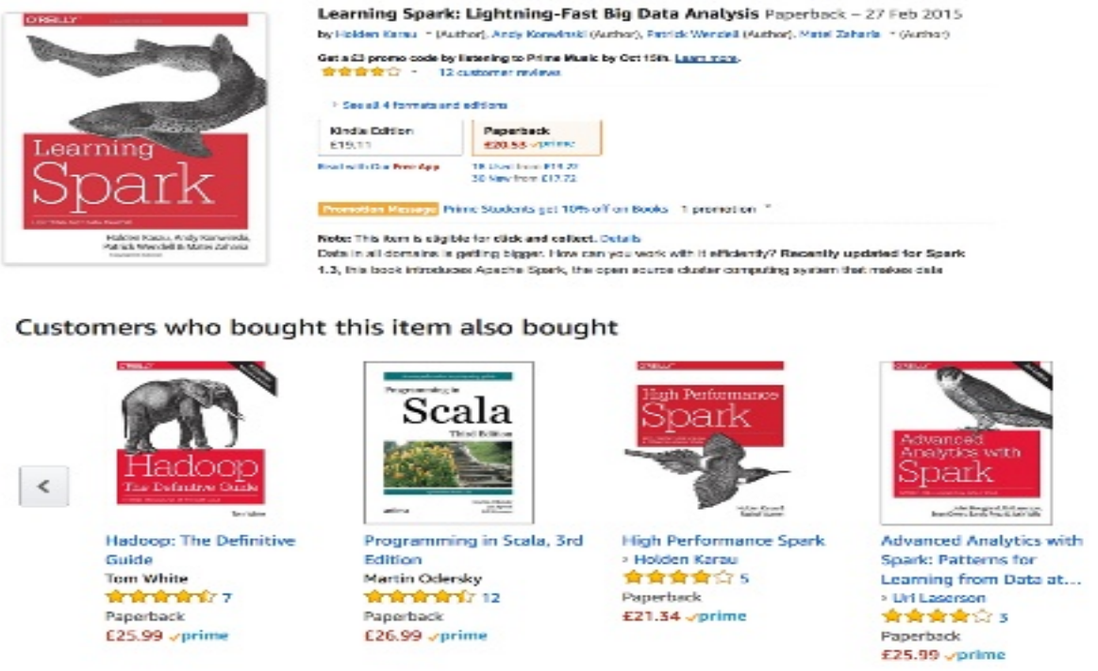
Learning to Rank

Model Evaluation



Images from: josuthea, kittyfiction, dailypakistan

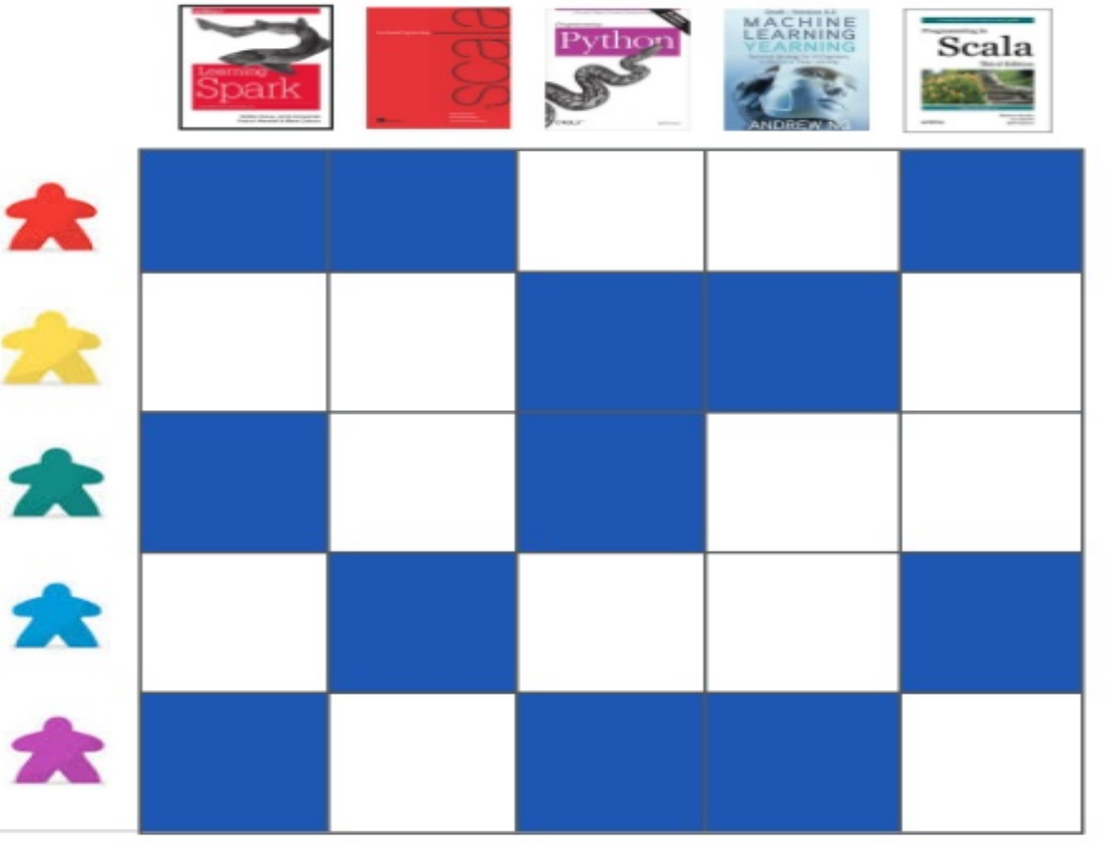
# Collaborative Filtering




- Widely used in the industry
- No knowledge about items or users
- Using the wisdom of crowds

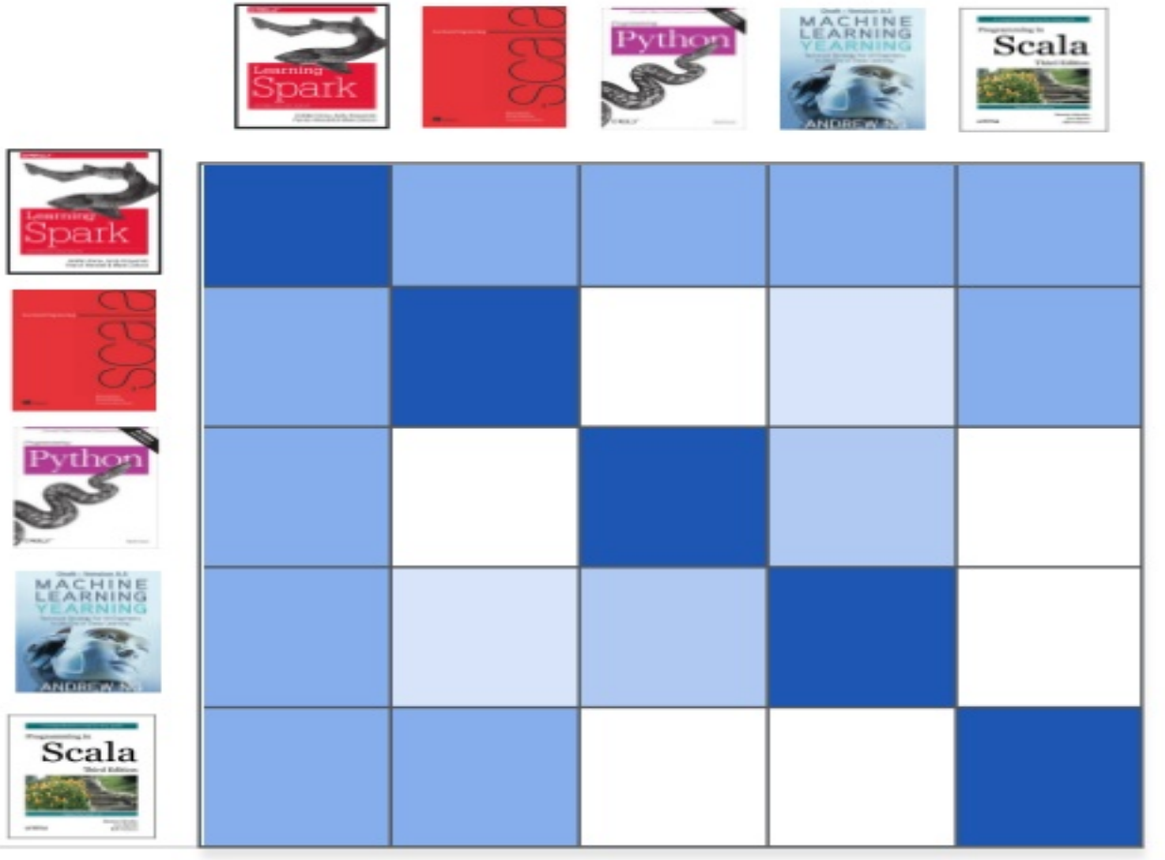
# Collaborative Filtering

- Usage matrix
- Browsing history
- User's who bought X also bought Y



# Item Based Collaborative Filtering

- Pairwise cosine similarity
- Similarity matrix
- K nearest–neighbors



# Item Based Collaborative Filtering

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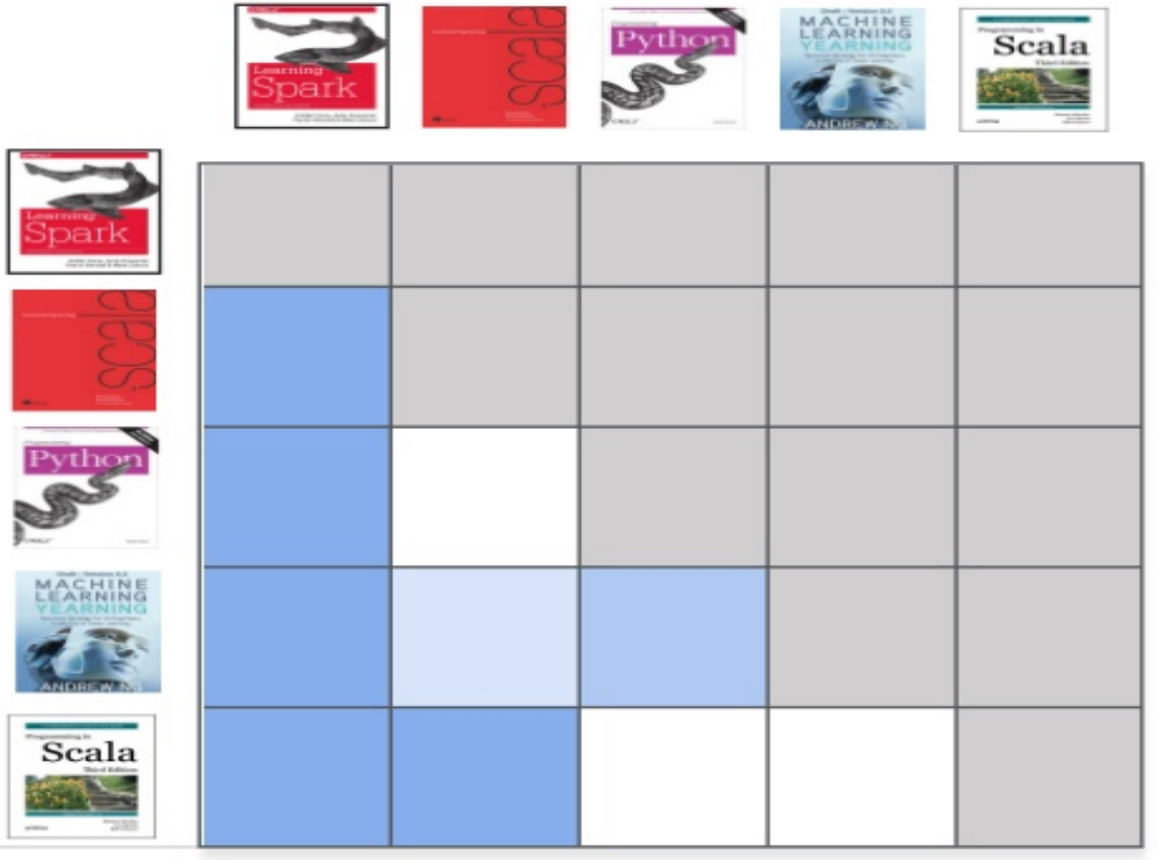
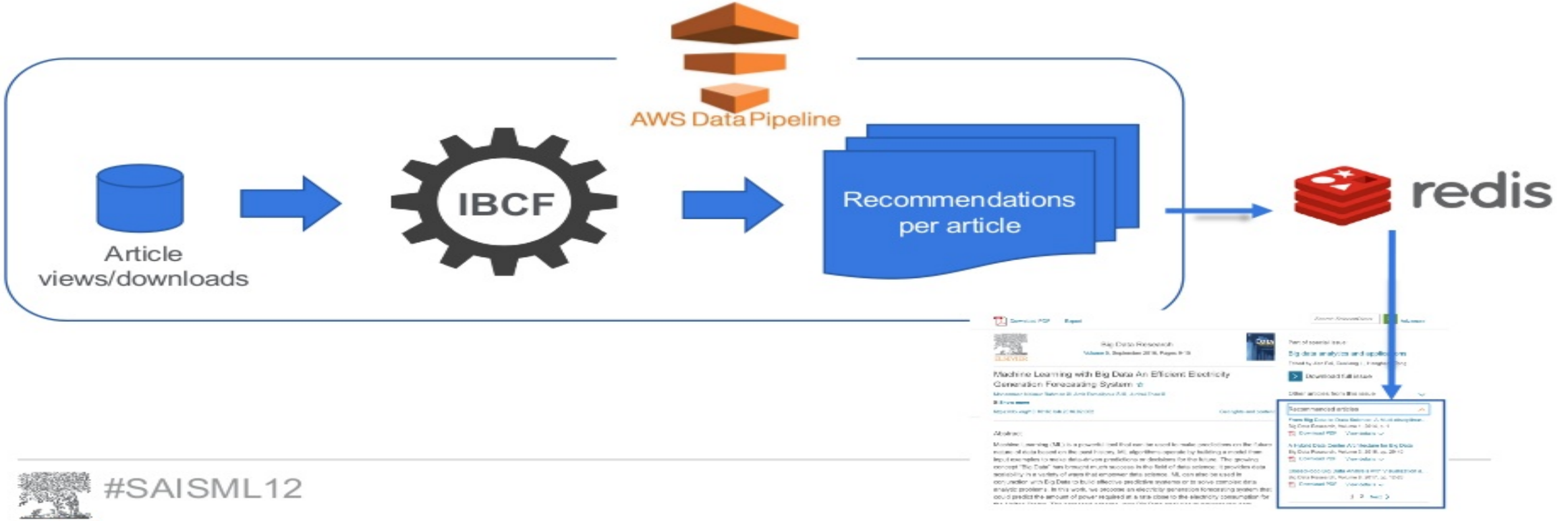


# Collaborative Filtering in production



# Can we do any better?



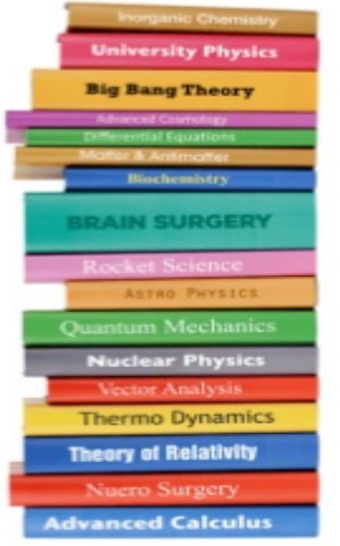
Image: shutterstock

# A wealth of features

$$\text{similarity} = \cos(\theta) = \frac{\mathbf{A} \cdot \mathbf{B}}{\|\mathbf{A}\|\|\mathbf{B}\|} = \frac{\sum_{i=1}^{n} A_i B_i}{\sqrt{\sum_{i=1}^{n} A_i^2}\sqrt{\sum_{i=1}^{n} B_i^2}}$$

CF score

Temporal




Subject

Popularity

Text



Images: wsj, alamy, bookedelic

# Learning to Rank (LtR)

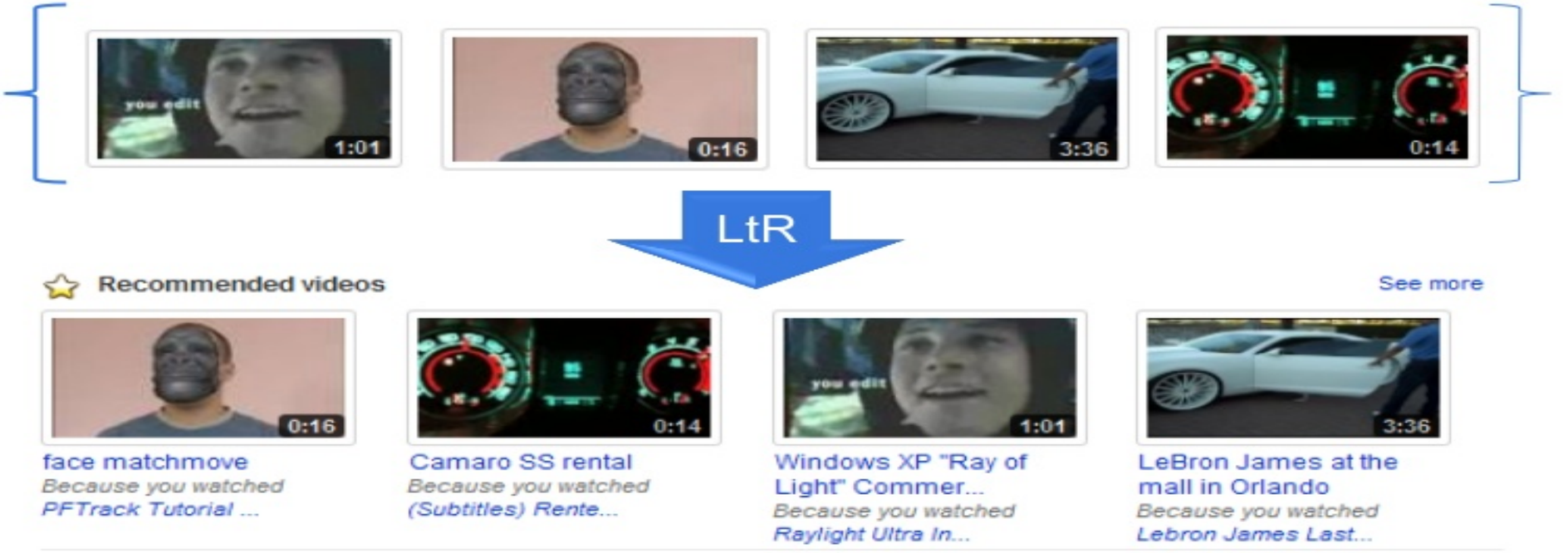





Image: hunterwalk.com

# LtR Model – Decision Tree

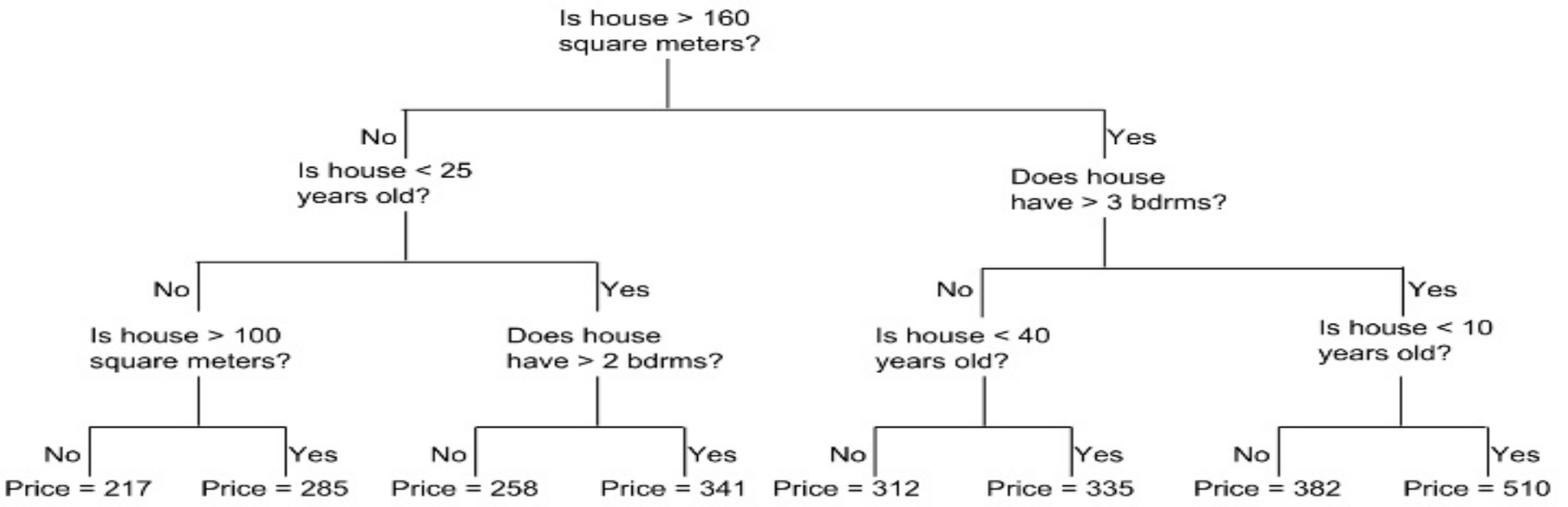
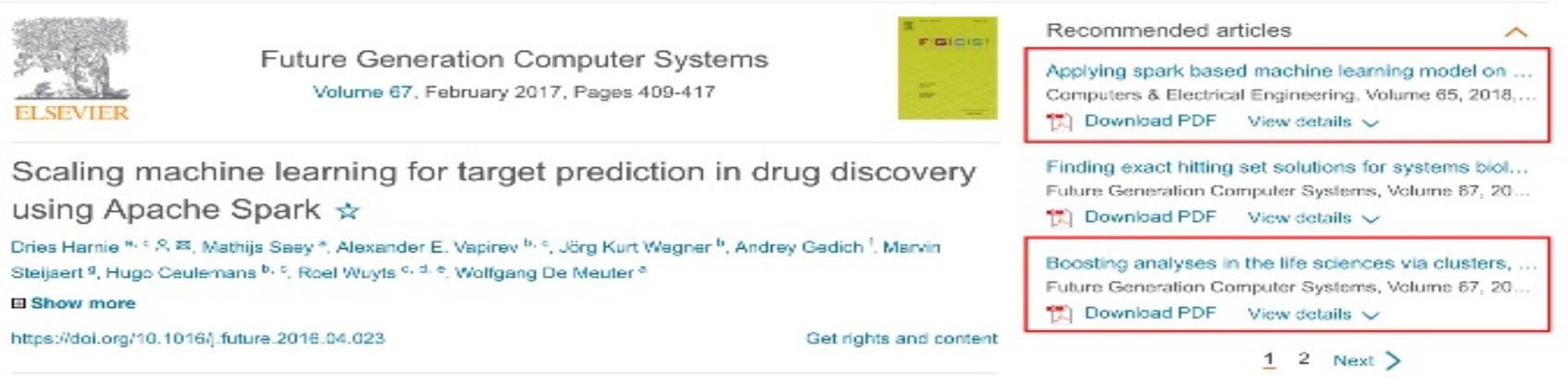





Image: Google machine learning glossary




**Gather data**

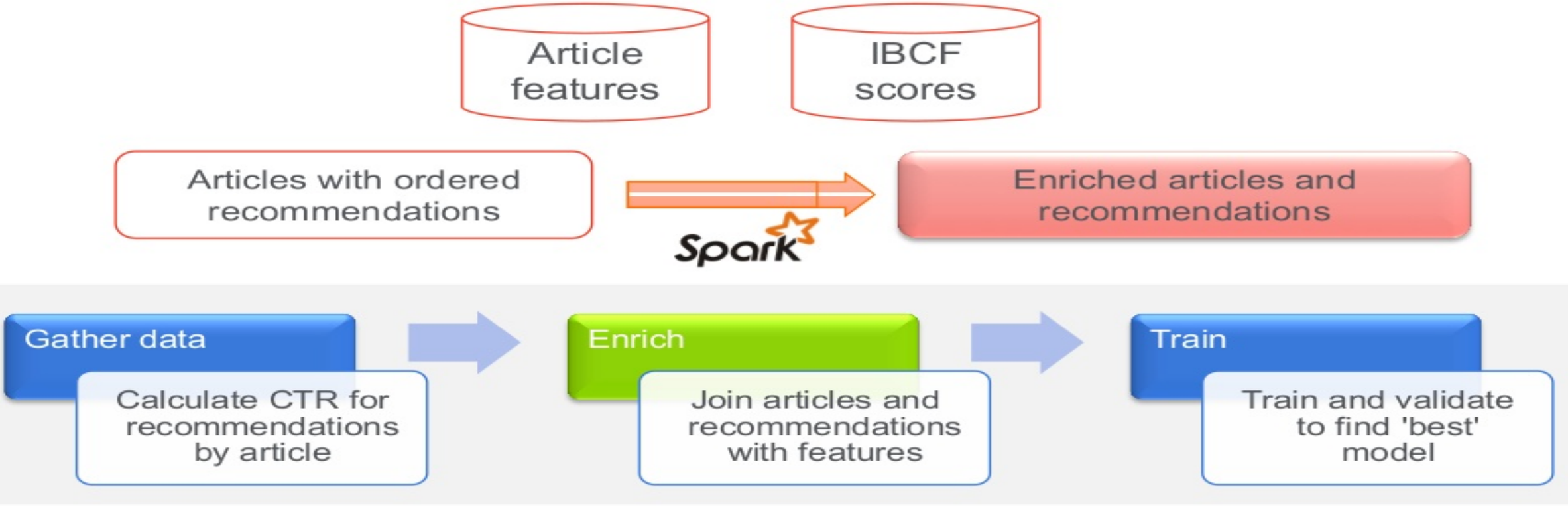
Calculate CTR for recommendations by article

**Enrich**

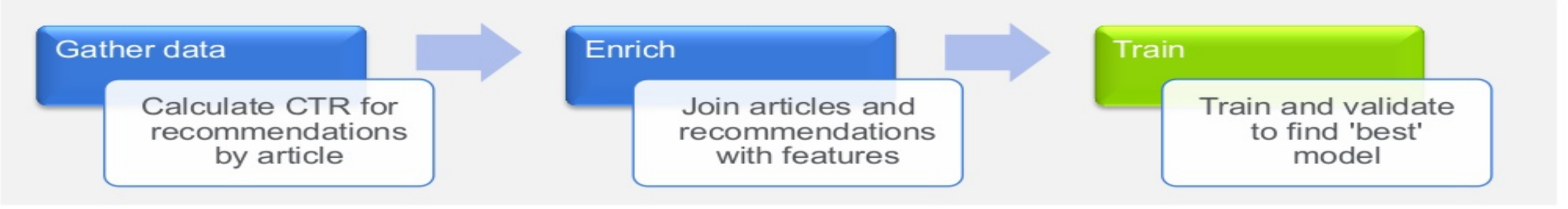
Join articles and recommendations with features

**Train**

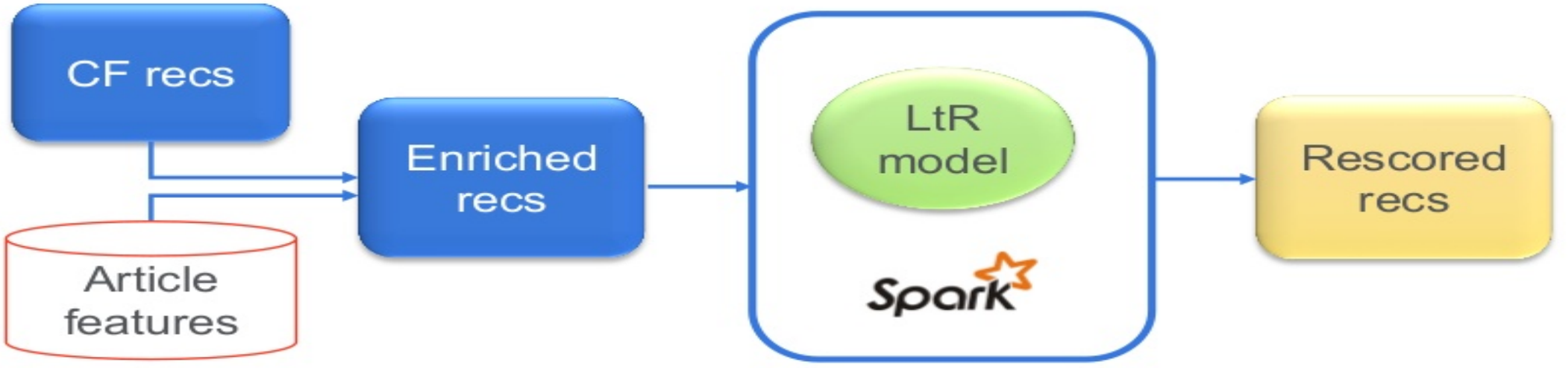
Train and validate to find 'best' model


Article features
IBCF scores
Articles with ordered recommendations
Spark
Enriched articles and recommendations
Gather data
Calculate CTR for recommendations by article
Enrich
Join articles and recommendations with features
Train
Train and validate to find 'best' model


Enriched articles and recommendations
Training (80%)
Validation (20%)
Model


Gather data
Calculate CTR for recommendations by article
Enrich
Join articles and recommendations with features
Train
Train and validate to find 'best' model

# Recommendation Rescoring



# Online model evaluation - A/B testing

# Result: **7-10%** improvement in user engagement



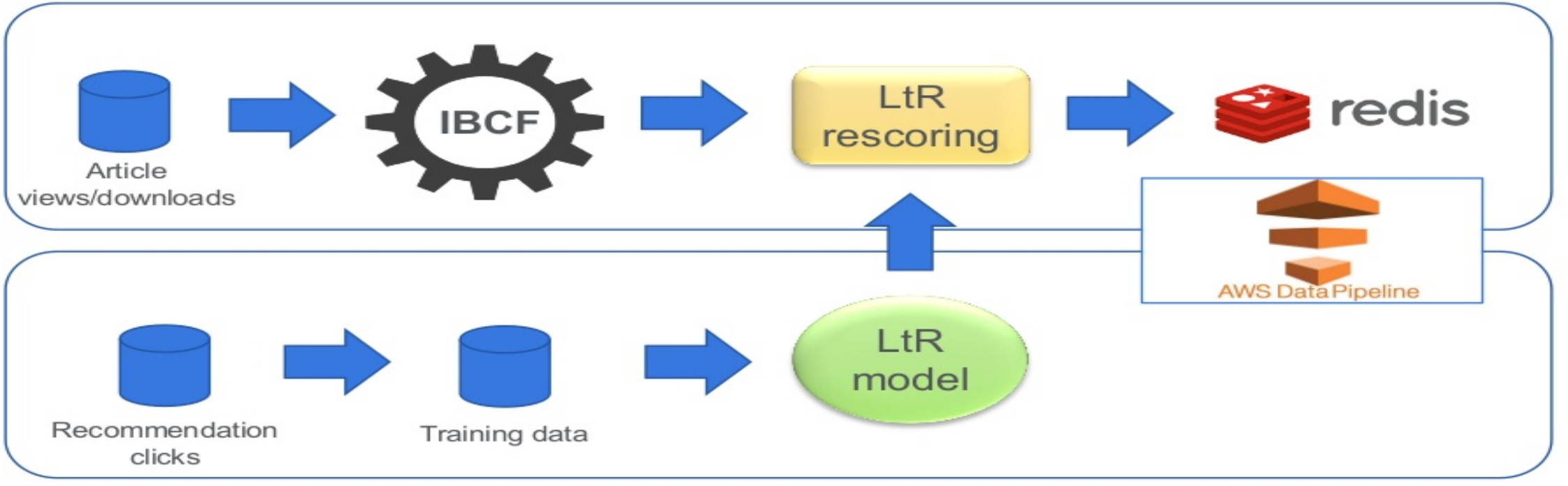
GIF: imgur

# Adaptive LtR Model – keep training




Image: pixabay

# Collaborative Filtering & Learning to Rank



# Conclusions

# Good recommendations can make a difference

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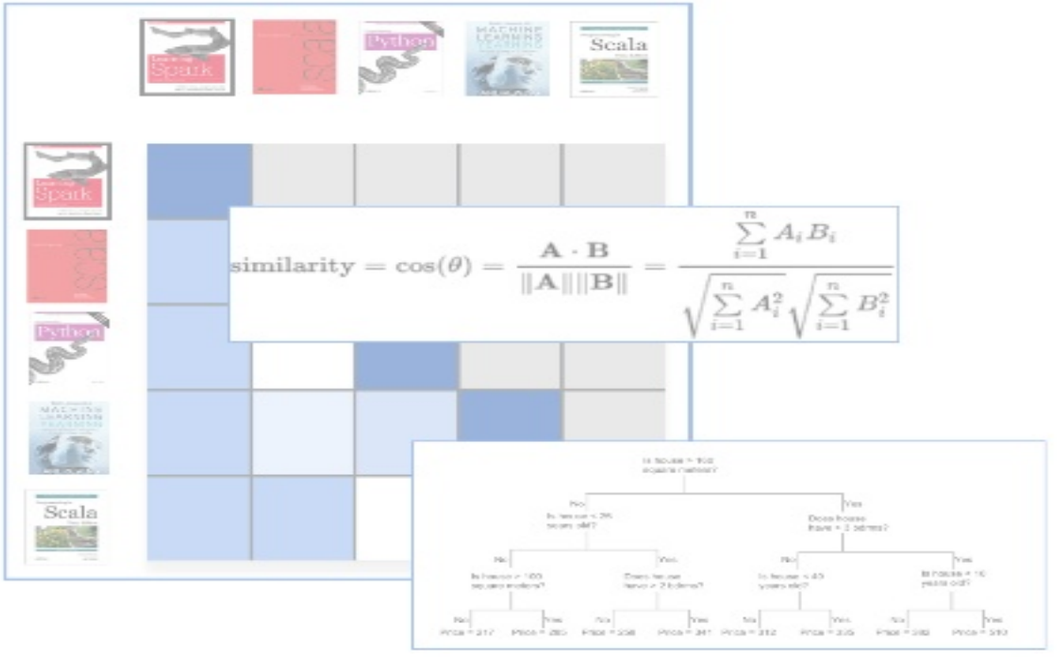


# Collaborative filtering and Learning to Rank work great!




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# Apache Spark is the foundation for scalable machine learning


image: ocado

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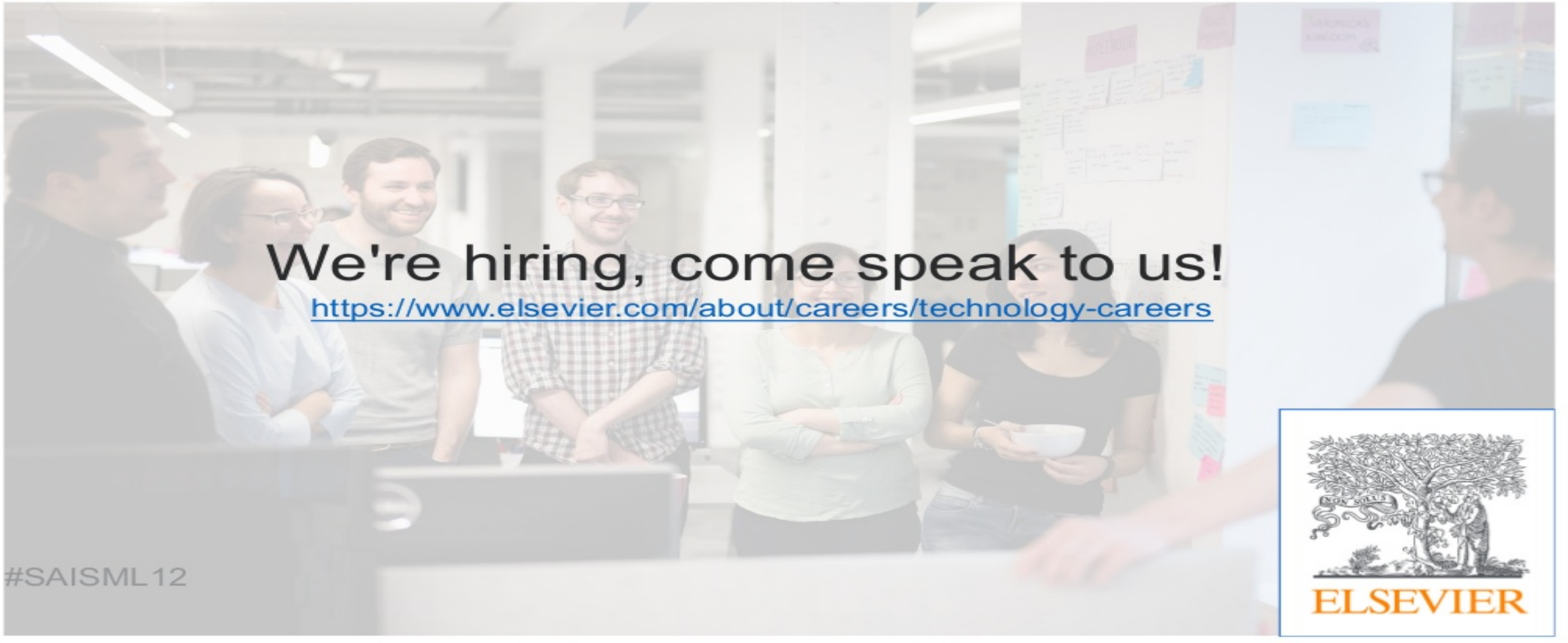
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# Thank you

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