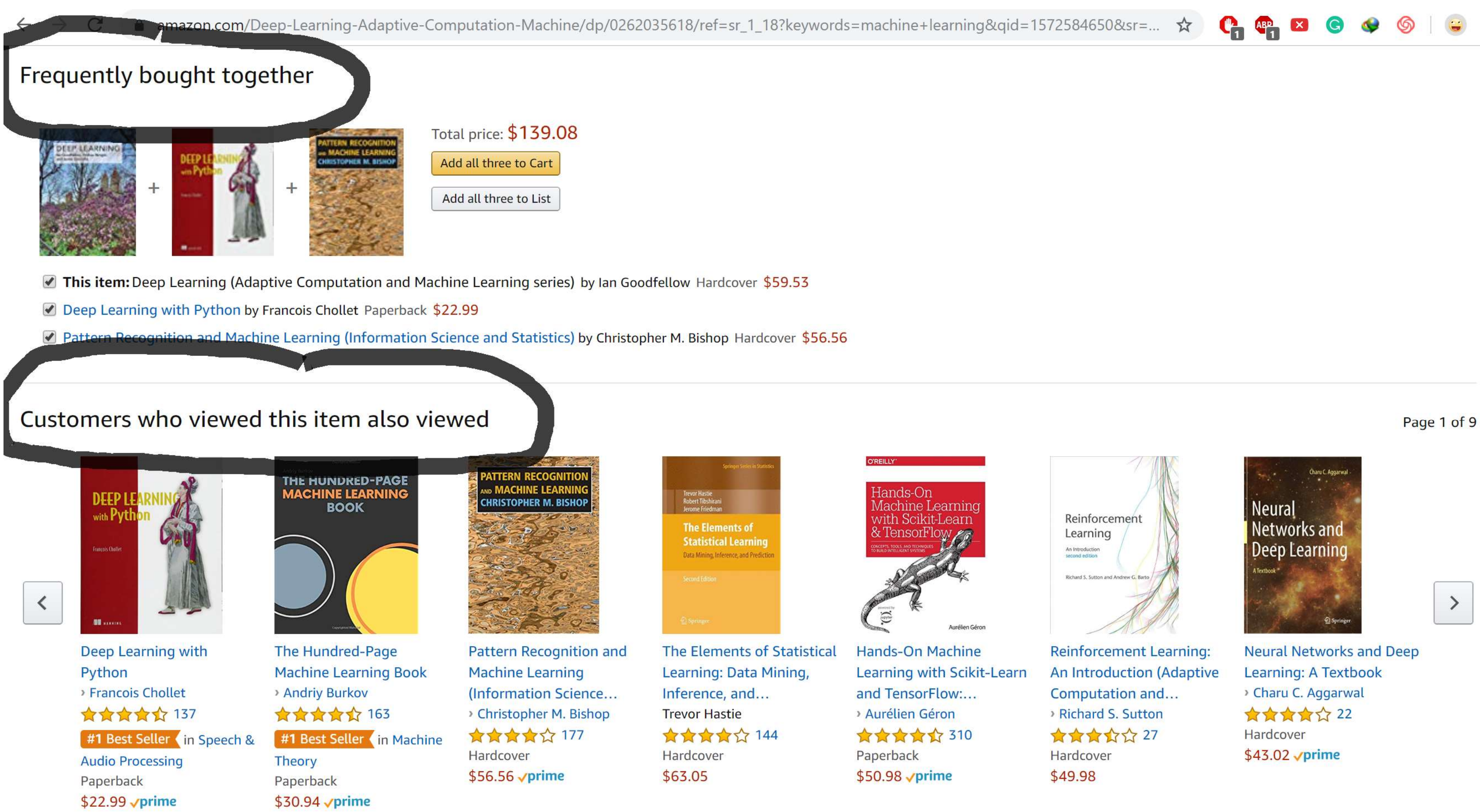
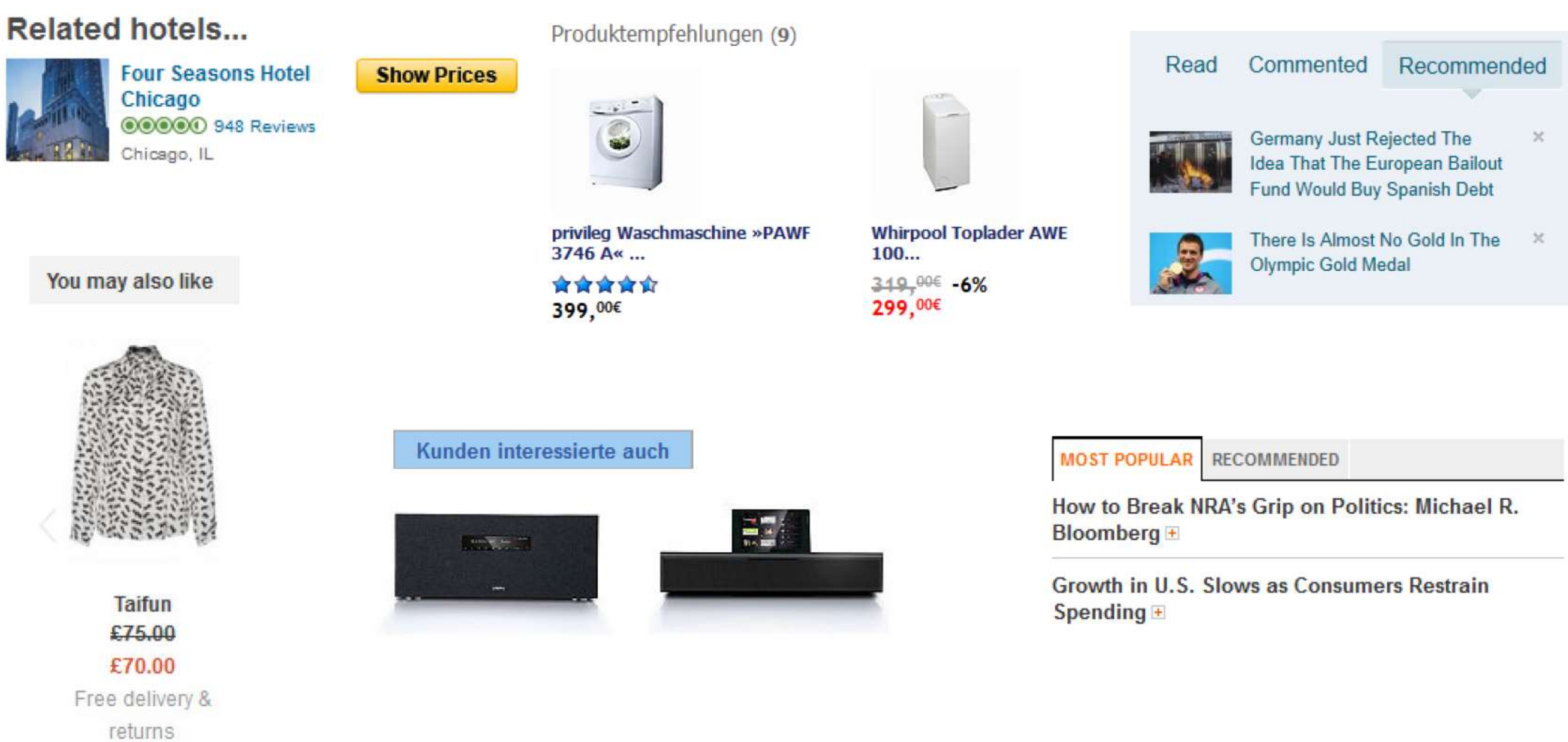
K-Nearest Neighbor (KNN)

Recommendation Systems

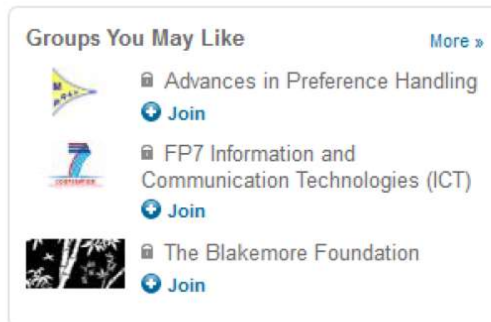
Examples - Amazon



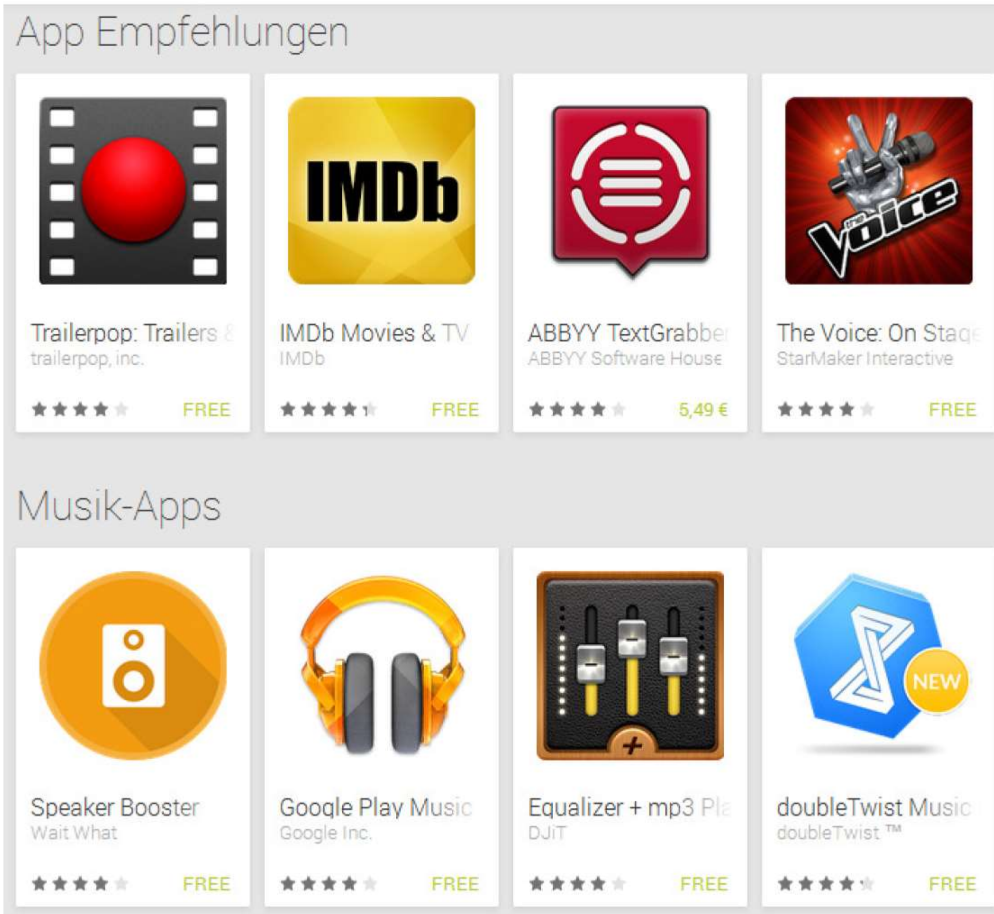
Examples - In e-commerce



Examples - In Social Media



Examples - Mobile Apps



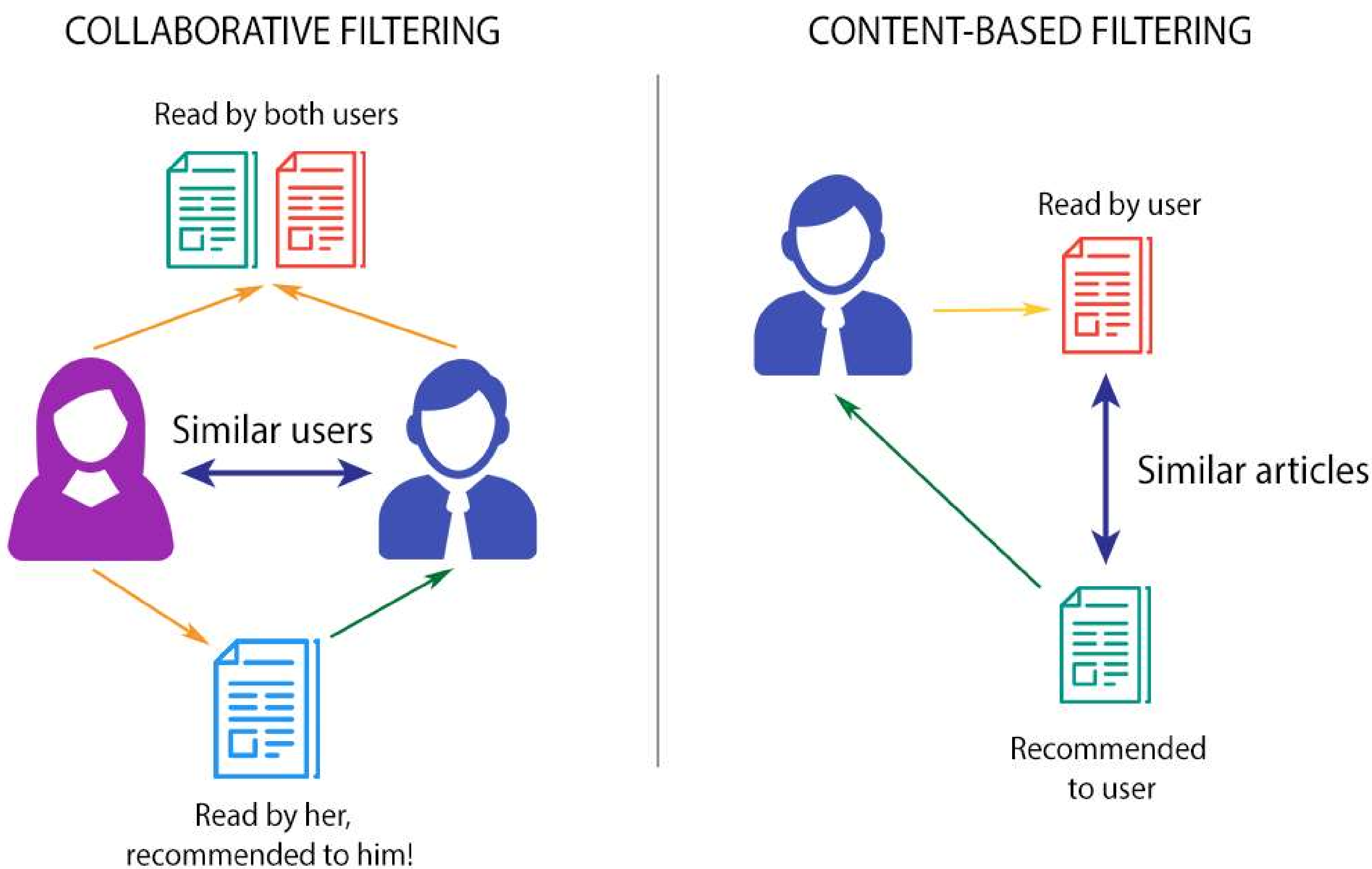
Definition - Problem domain

- Recommendation systems (RS) help to match **users** with **items**

Definition - Problem domain

– RS are one of the **most successful and widespread applications** of machine learning technologies in business.

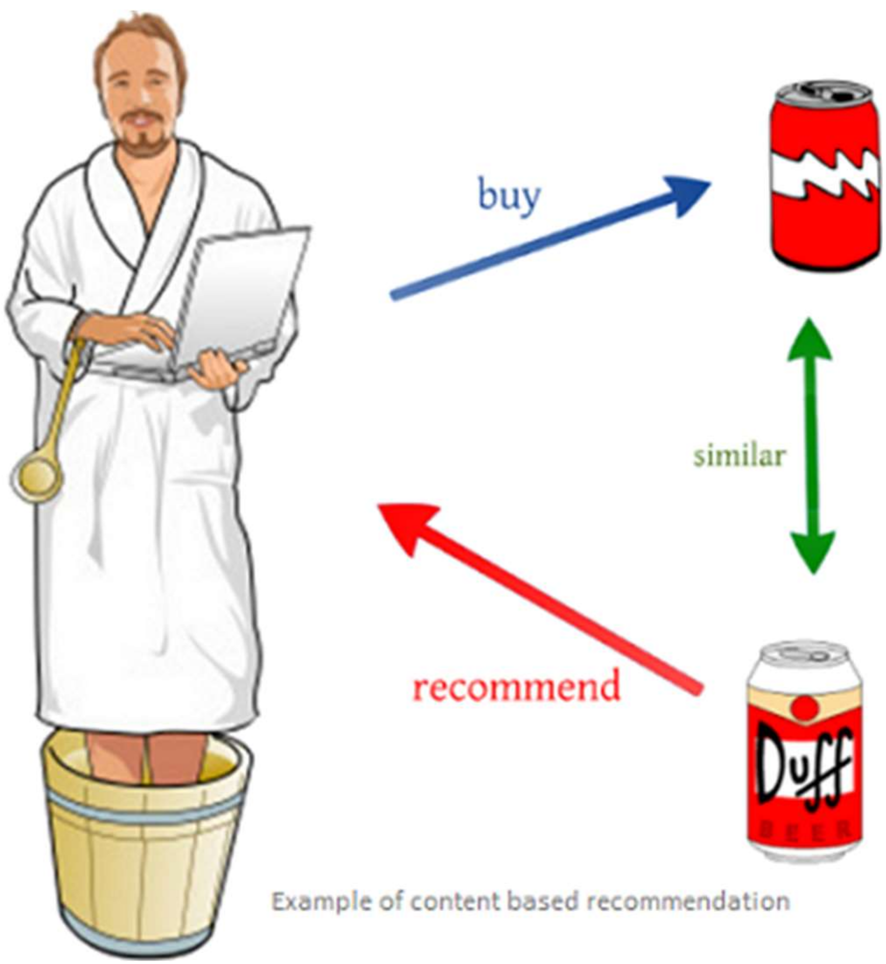
Two types of systems


COLLABORATIVE FILTERING
Read by both users
Similar users
Read by her,
recommended to him!
CONTENT-BASED FILTERING
Read by user
Similar articles
Recommended
to user

Two types of systems

- **Content- Based Filtering**: Recommeding to user A based on his/her existing profiles.
- **Collaborative Filtering**: Recommeding to user A based on his/her community's profiles.

Content- Based Filtering

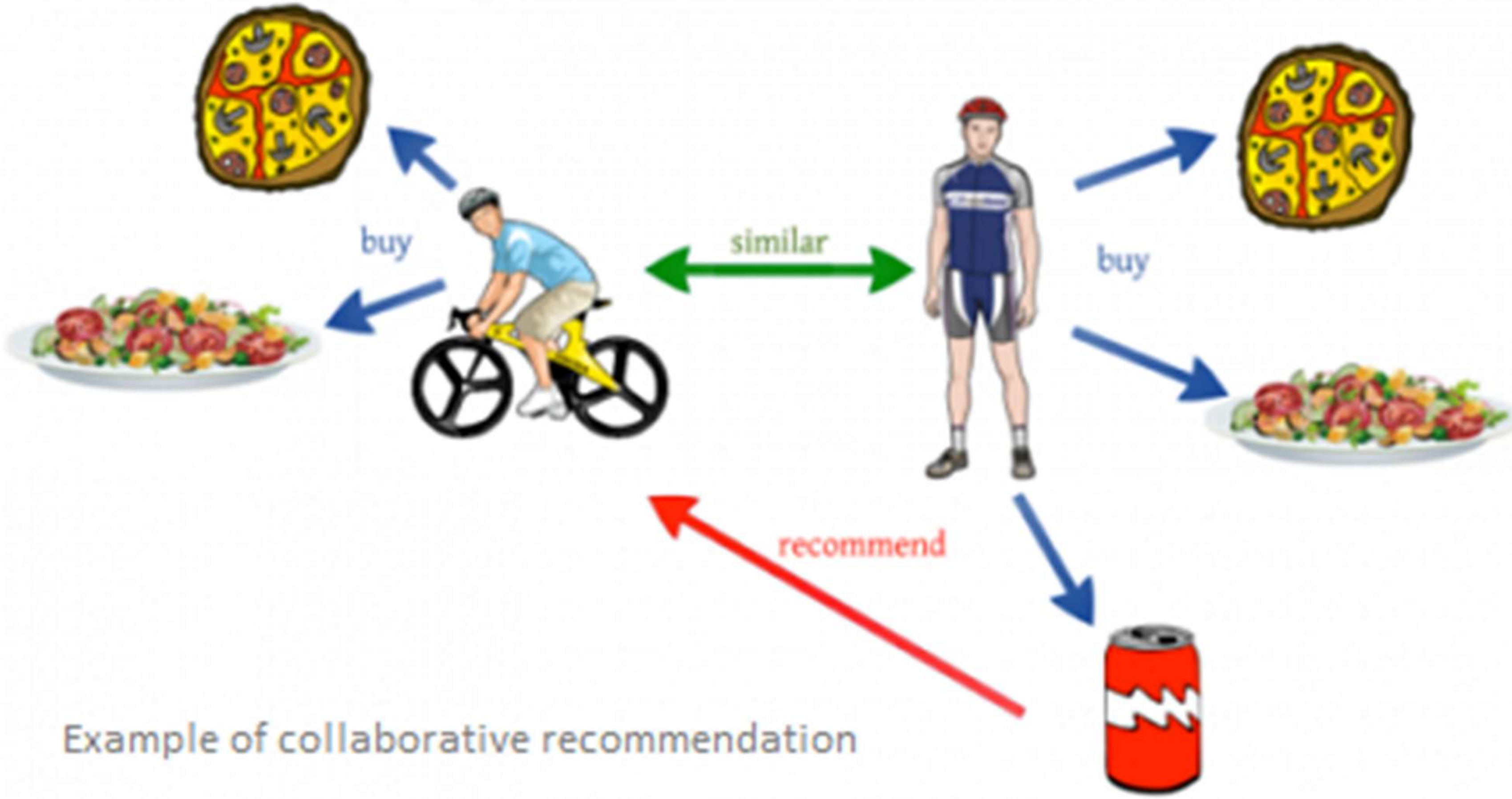


Example of content based recommendation

Content- Based Filtering

- Assume there are four categories of news A) Politics B) Sports C) Entertainment D) Technology
- User A who has read 10 articles related to Technology
- Recommend a new article in Technology for him to read.

Collaborative Filtering

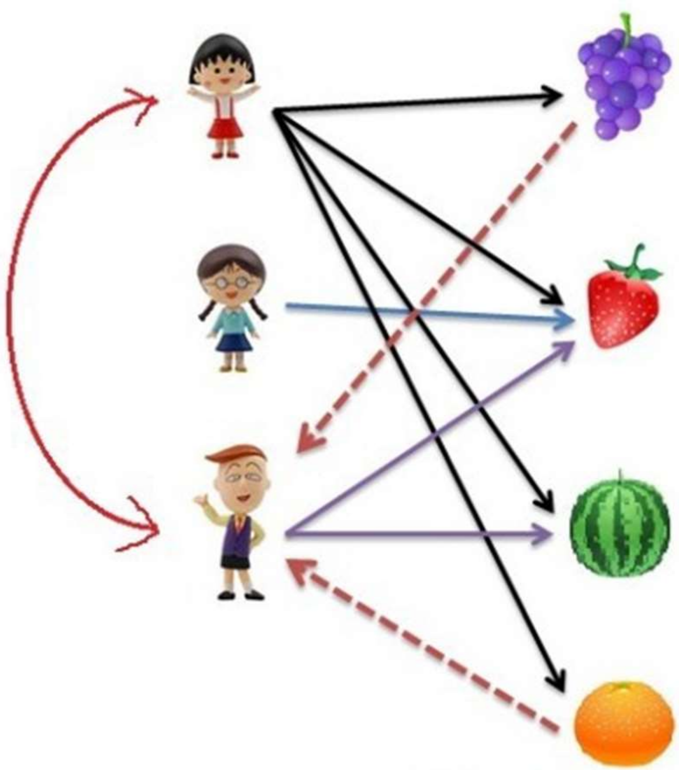


Example of collaborative recommendation

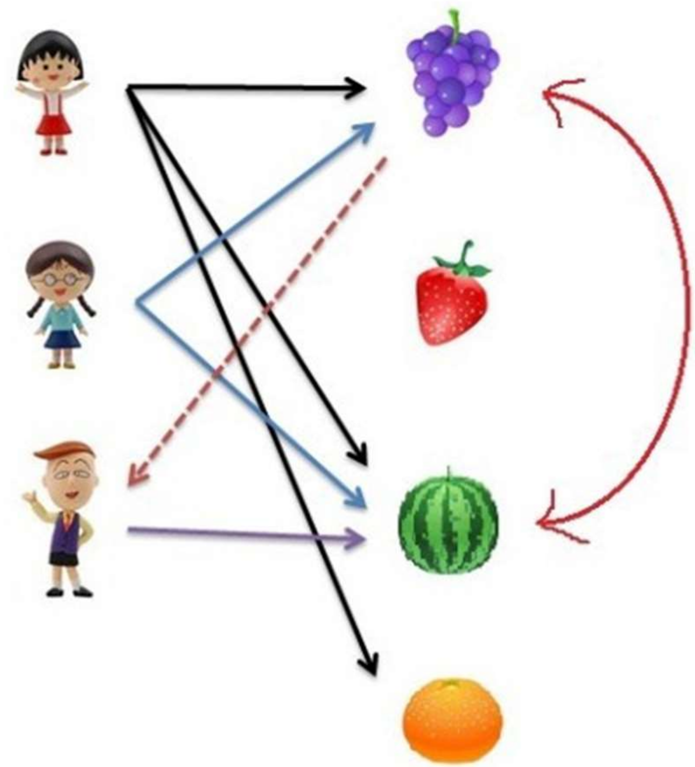
Collaborative Filtering

- Assume there are four categories of news A) Politics B) Sports C) Entertainment D) Technology
- User A who has read 10 articles related to Technology
- User B who has read **the same** 10 articles related to Technology and an X article in Sports.
- Recommend the article X to user A.

Collaborative Filtering: Two approaches



User-based filtering



Item-based filtering

Utility Matrix

– Utility Matrix contains ratings of users on items

	Item 1	Item 2	Item 3	Item 4	Item 5
Alice	5	3	4	4	???
User 1	3	1	2	3	3
User 2	4	3	4	3	5
User 3	3	3	1	4	4
User 4	1	5	5	2	1

- A **recommendation problem** tunrs into a **prediction problem**.
- Predict the rating of the new user on his/her new item.
- If the predicted rating of *Alice* on Item 5 are high (4 or 5), we will recommend Item 5 to her.

Nearest-neighbors (kNN)

- A “pure” CF approach and traditional baseline
- Using the utility as inputs
- Returns a ranked list of items based on rating predictions

Nearest-neighbors (kNN)

- **Assumptions**
  - If users had similar tastes in the past they will have similar tastes in the future
  - User preferences remain stable and consistent over time

User-based KNN

	Item 1	Item 2	Item 3	Item 4	Item 5
Alice	5	3	4	4	???
User 1	3	1	2	3	3
User 2	4	3	4	3	5
User 3	3	3	1	4	4
User 4	1	5	5	2	1

- Find find k nearst neighbors of Alice.
- User the average rating of the nearest neighbors on Item 5 as a prediction of Alice on Item 5.

User-based KNN

Let $A1$ is the distance from Alice to User 1 and so on. We have:

A1 = 3.60

A2 = 1.41

A3 = 3.60

A4 = 5

- For 3NN, the predicted rating of Alice for item 5 is the average of ratings on item 5 of her 3 neast neighbors, User 1, 2 and 3.
- Predicted rating of Alicie on item 5 is: (3+5+4)/3 =

Item-based KNN

	Item 1	Item 2	Item 3	Item 4	Item 5
Alice	5	3	4	4	???
User 1	3	1	2	3	3
User 2	4	3	4	3	5
User 3	3	3	1	4	4
User 4	1	5	5	2	1

- Find the k nearest neighbors of **Item 5**.
- The predicted rating of Alice on item 5 is the average rating of Alice on the nearest neighbors.

Item-based KNN

Let $d54$ be the distance of item 5 to item 4 and so on. We have

d54 = 2.23

d53 = 5.19

d52 = 5

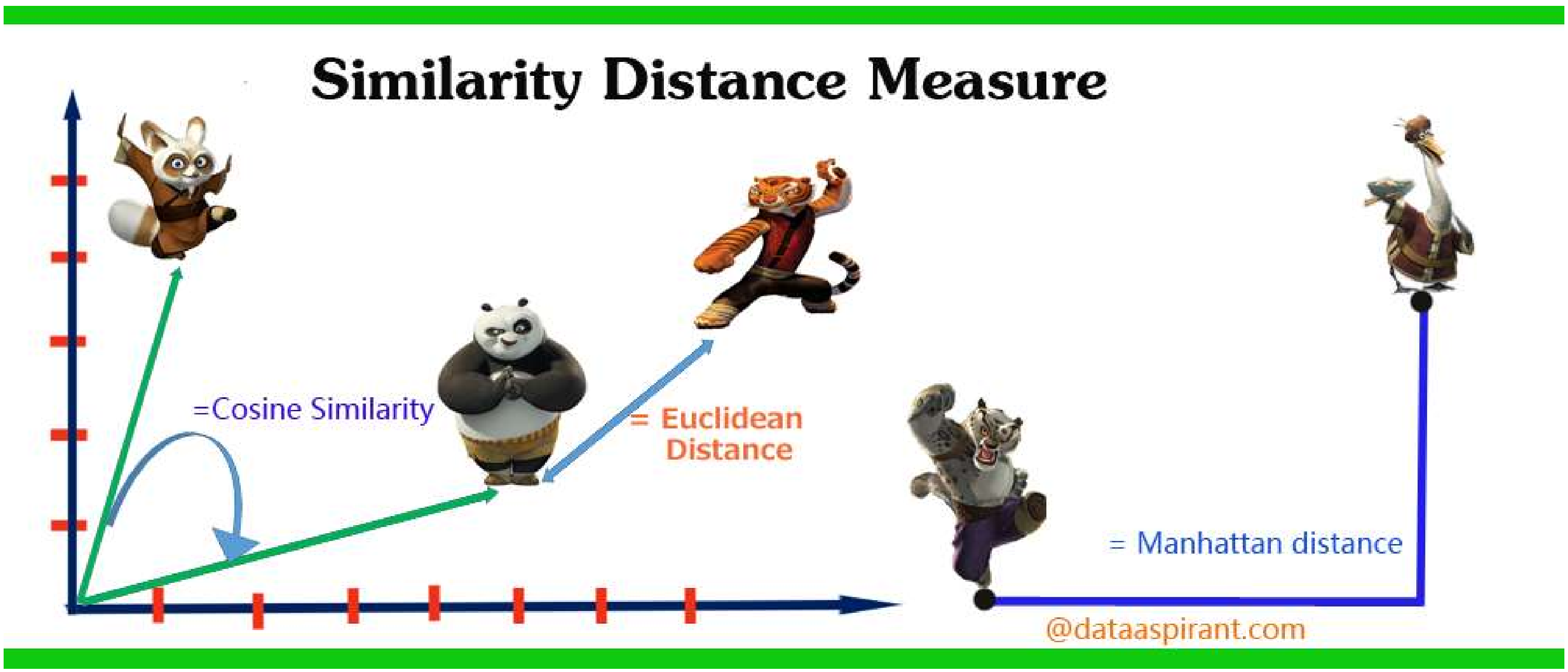
d51 = 1.41

- For 3NN, the two nearest neighbors of Item 5 are Item 1,4 and Item 2.
- Predicted rating of Alice on Item 5 is the average of her ratings on Item 1, 4 and 2, which is

Similarity Measure

- Neighborhood can be decided by **similarity** measures
- Similarity can be measured as the inverse of the Distance
- The possible similarity values are between 0 and 1, where values near to 1 indicate a strong similarity.
- There are many distance measure
- There are many similarity measure

Similarity Measure


Similarity Distance Measure
=Cosine Similarity
= Euclidean Distance
= Manhattan distance
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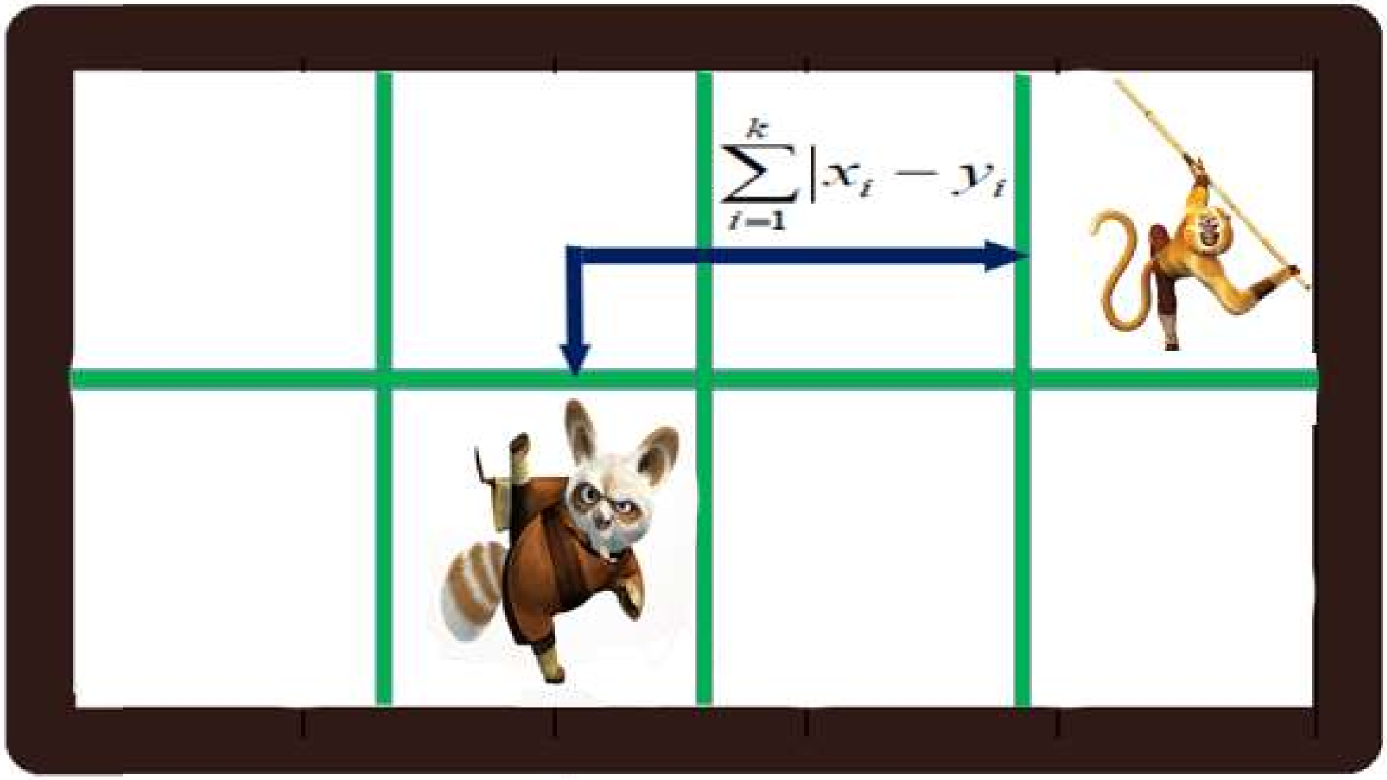
Manhattan Distance

Manhattan Distance



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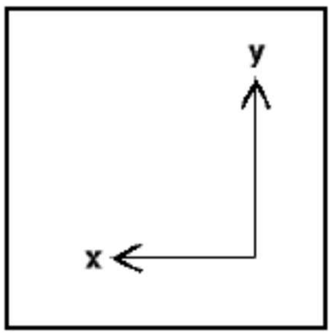
Manhattan Distance

– ManhattanDistance between Alice and User 1 ($A1$).

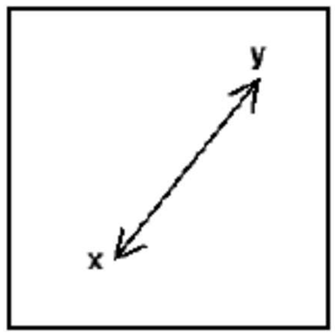
	Item 1	Item 2	Item 3	Item 4
Alice	5	3	4	4
User 1	3	1	2	3

$$A1 = |5 - 3| + |3 - 1| + |4 - 2| + |4 - 3| = 7$$

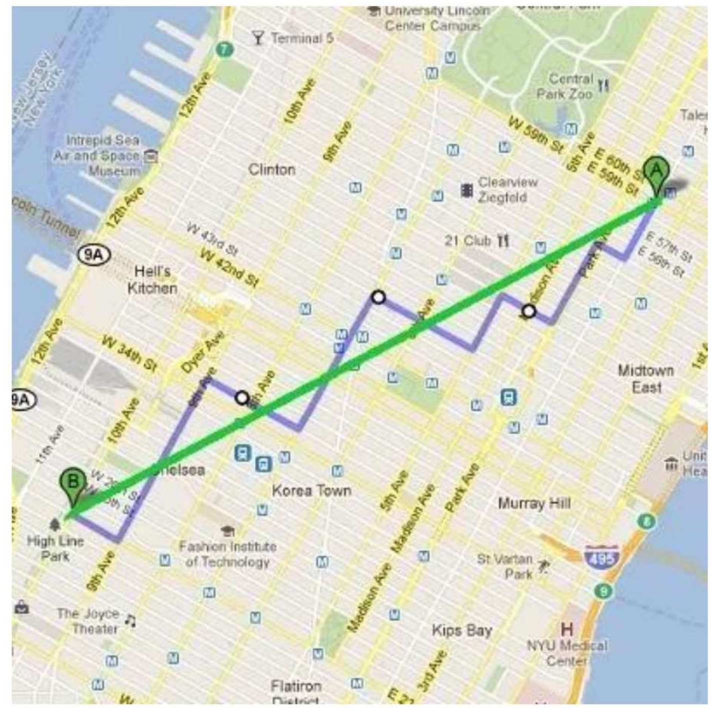
Manhattan vs. Euclidean



Manhattan



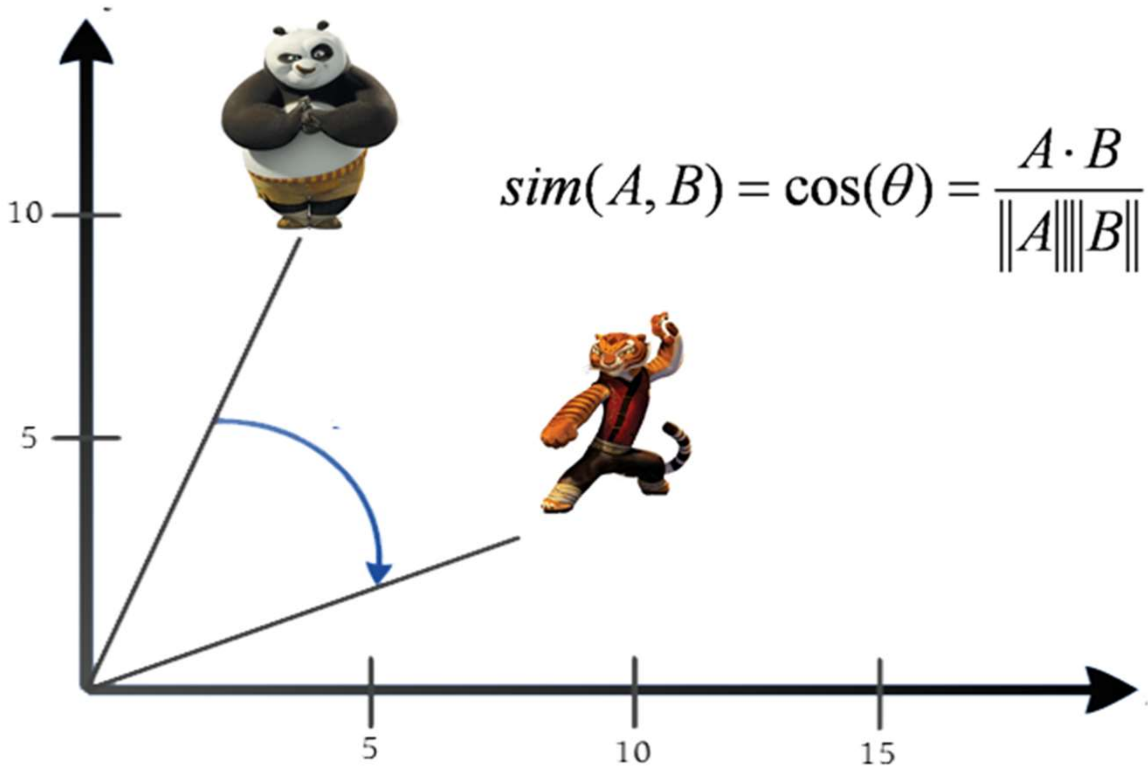
Euclidean



Cosine Similarity

Cosine Similarity

$$sim(A,B) = \cos(\theta) = \frac{A \cdot B}{\|A\|\|B\|}$$



– **Cosine similarity** is established as the standard in Recommendation System.

Cosine Similarity Measure

– Cosine similarity between Alice and User 1 ($S1$).

	Item 1	Item 2	Item 3	Item 4
Alice	5	3	4	4
User 1	3	1	2	3

$$S1 = \frac{5 \cdot 3 + 3 \cdot 1 + 4 \cdot 2 + 4 \cdot 3}{\sqrt{5^2 + 3^2 + 4^2 + 4^2} \cdot \sqrt{3^2 + 1^2 + 2^2 + 3^2}} = 0.975$$

The Netflix Challenge

[Link]