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MODENA E REGGIO EMILIA

Tecnologie Web

Recommendation Systems

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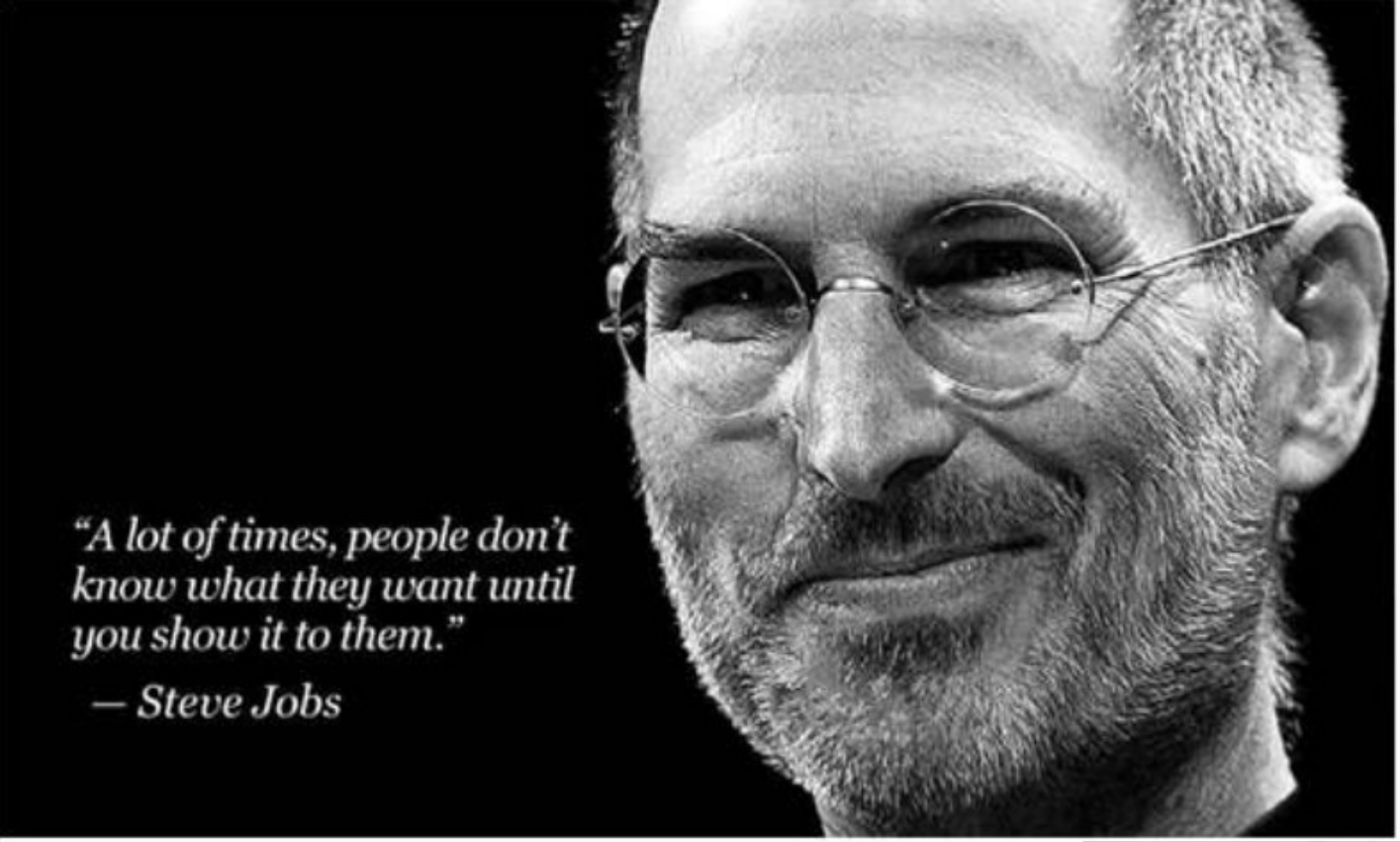
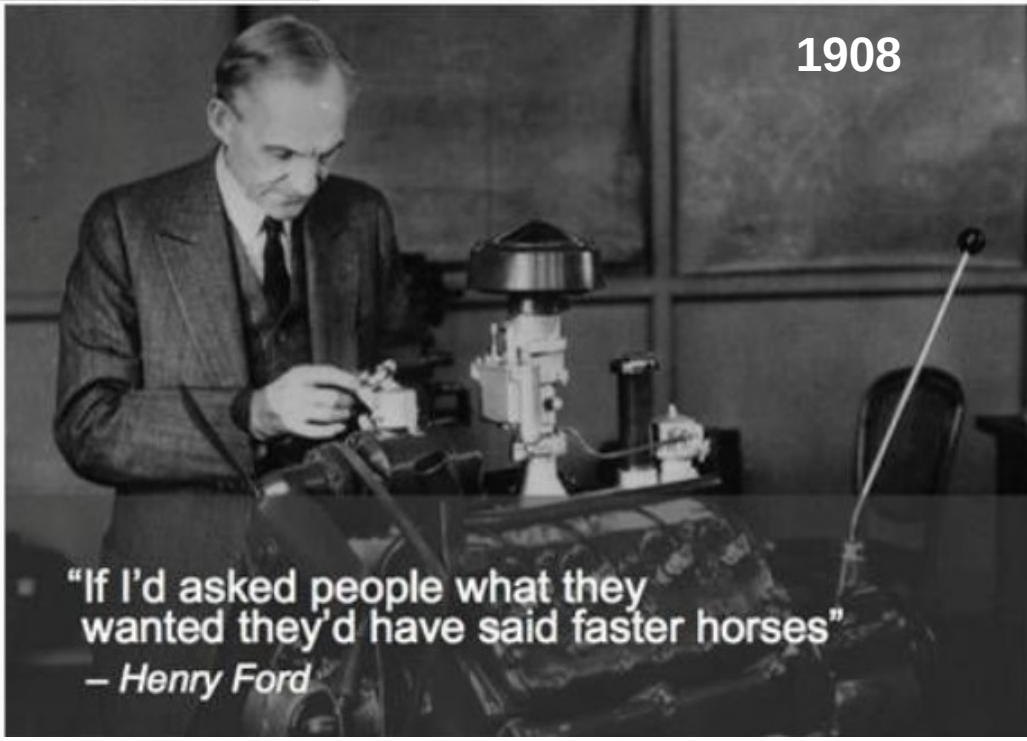
How computers **know** **what** we really **want**?



People don't know what they want until you recommend it to them.



The worls of recommendation system

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Amazon Recommendation Engine

The worlds of recommendation systems

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Modalità di classificazione di questi articoli

Le tue notizie

venerdì 24 marzo

Rivoli 14 °C weather.com

Notizie principali

"Disgelo Meloni-Macron": faccia a faccia in hotel su migranti e nucleare. La...
3 ore fa

la Repubblica
Sui migranti Meloni rimasta sola chiede aiuto al "nemico" Macron
12 ore fa

Agenzia ANSA
Meloni attacca su Patto e migranti, disgelo con Macron - Europa
15 ore fa

Il Sole 24 ORE
Vertice Ue, dalla strategia per la competività al patto di stabilità: ecco cosa c'è nell'agenda. Le ...
Ieri

Copertura completa

Agenzia ANSA
In Francia continua la protesta contro la riforma delle pensioni, guerriglia a Parigi -...
13 ore fa

Corriere della Sera
Pensioni in Francia, cosa prevede e quando verrà introdotta la riforma voluta da Macron
17 ore fa

TGCOM
Riforma delle pensioni in Francia, manifestazioni in tutto il Paese: oltre 120 agenti feriti, più di 170 fermi
13 ore fa

Il Tempo
Riforma pensioni Francia, Contro Macron chiusa la Torre Eiffel
3 ore fa • Editoriale

Copertura completa

Notizie locali

TORINOTODAY
A Venaria Reale ha aperto il supermercato ALDI: prezzi vantaggiosi, qualità e 16 nuovi pos...
3 ore fa

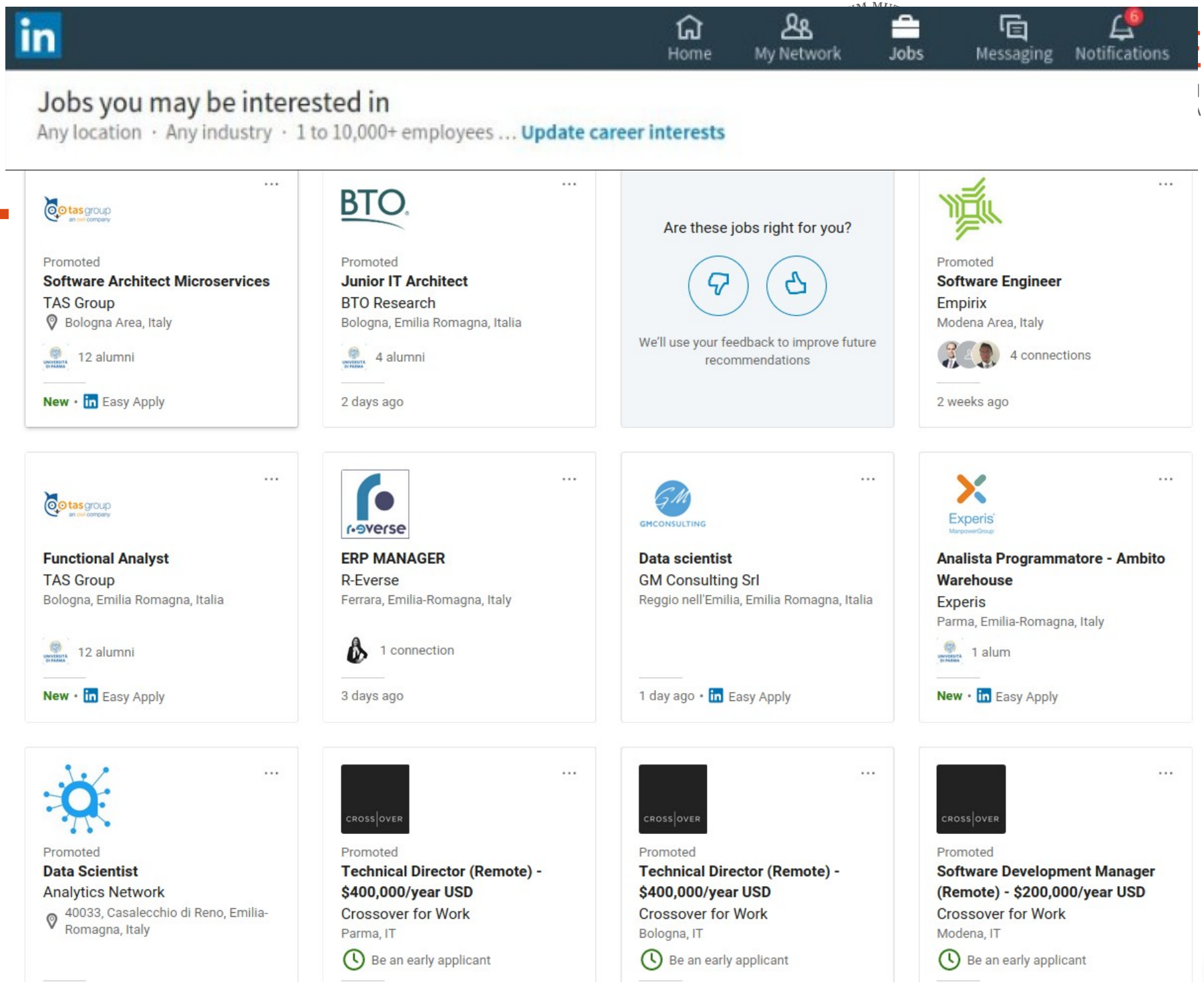
TorinOggi
Con 'Cabaret' e 'Chicago' si canta e si balla alla Palazzina di Stupinigi
2 ore fa

Luna Nuova
Rivoli, allarme per polvere sospetta al Bosco della Stella
12 ore fa

Scelti per te

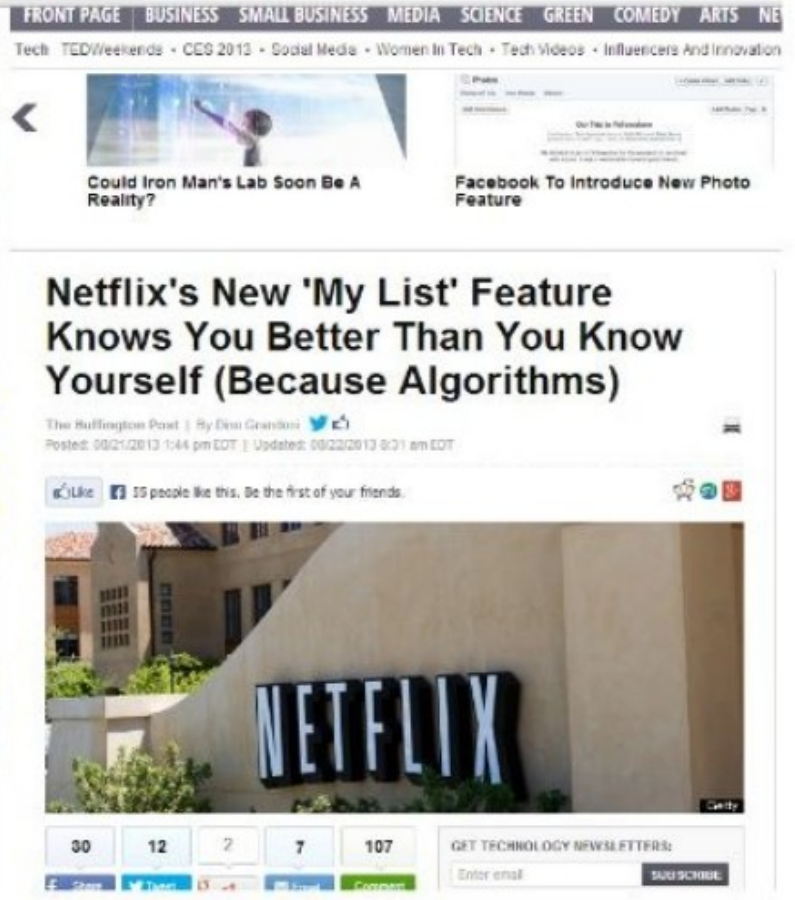
fanpage
Ellynora massacrata per l'inno cantato prima di Italia-Inghilterra: È vergognoso, chiunque sia
12 ore fa

24 ORE
Partite Iva, uscire dai debiti? La strada del concordato preventivo

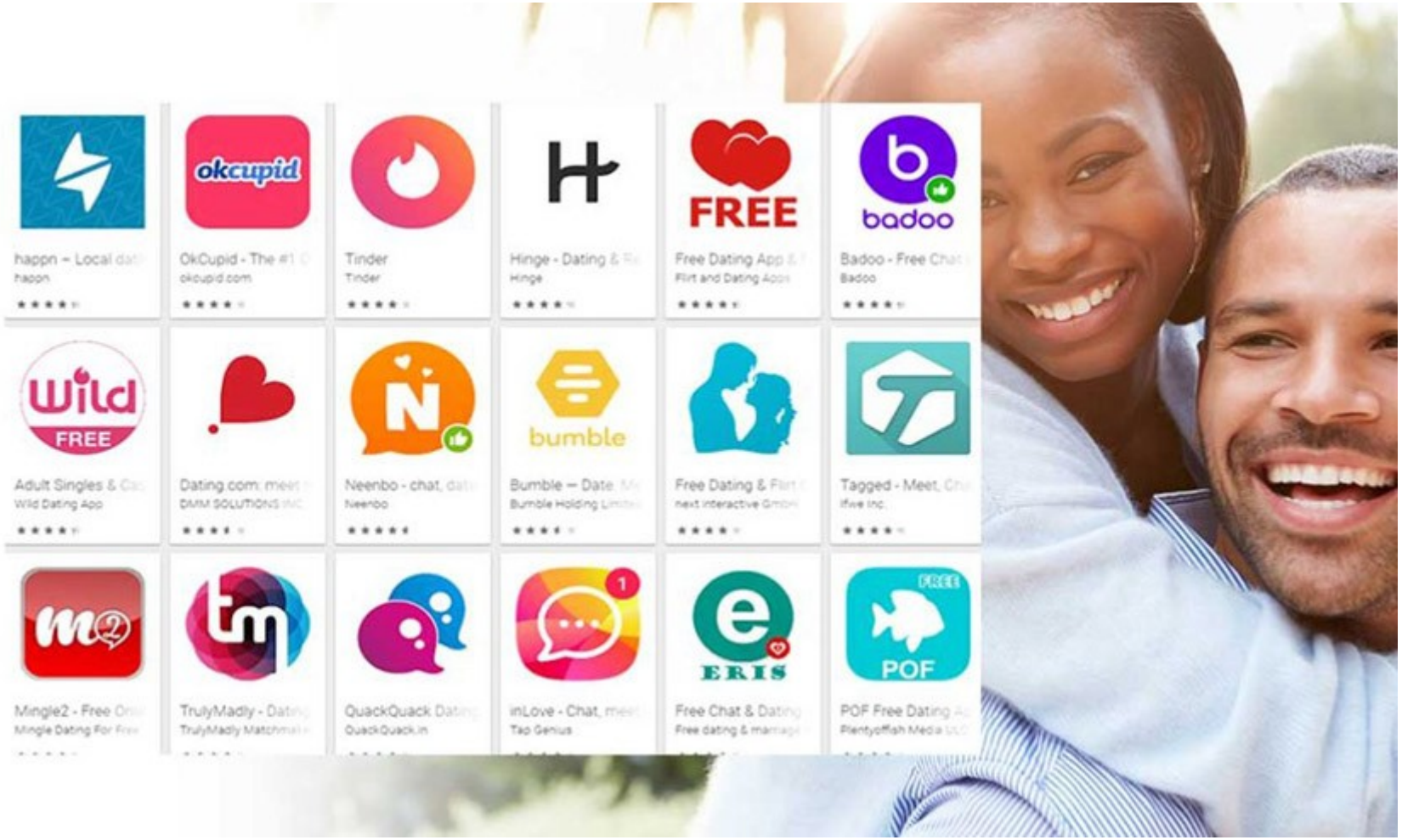


LinkedIn "Jobs you may be interested in"

EVERYTHING is a Recommendation



Even dating!



Why recommendation system?

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Business model

1)Two-thirds of movies watched by Netflix customers are recommended movies

2) 38% of click-through rates on Google News are recommended links

3) 35% of sales at Amazon arise from recommended products

How it works?

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How do the main Web players use recommendation systems?

1)What they track

2)How they use tracked data

Let's reason about that…

Amazon? Netflix? Twitter?

How it works?

How do the main Web players use recommendation systems?

1)What they track

2)How they use tracked data

Let's reason about that…

Amazon? Netflix? Twitter?

What is a recommendation system?

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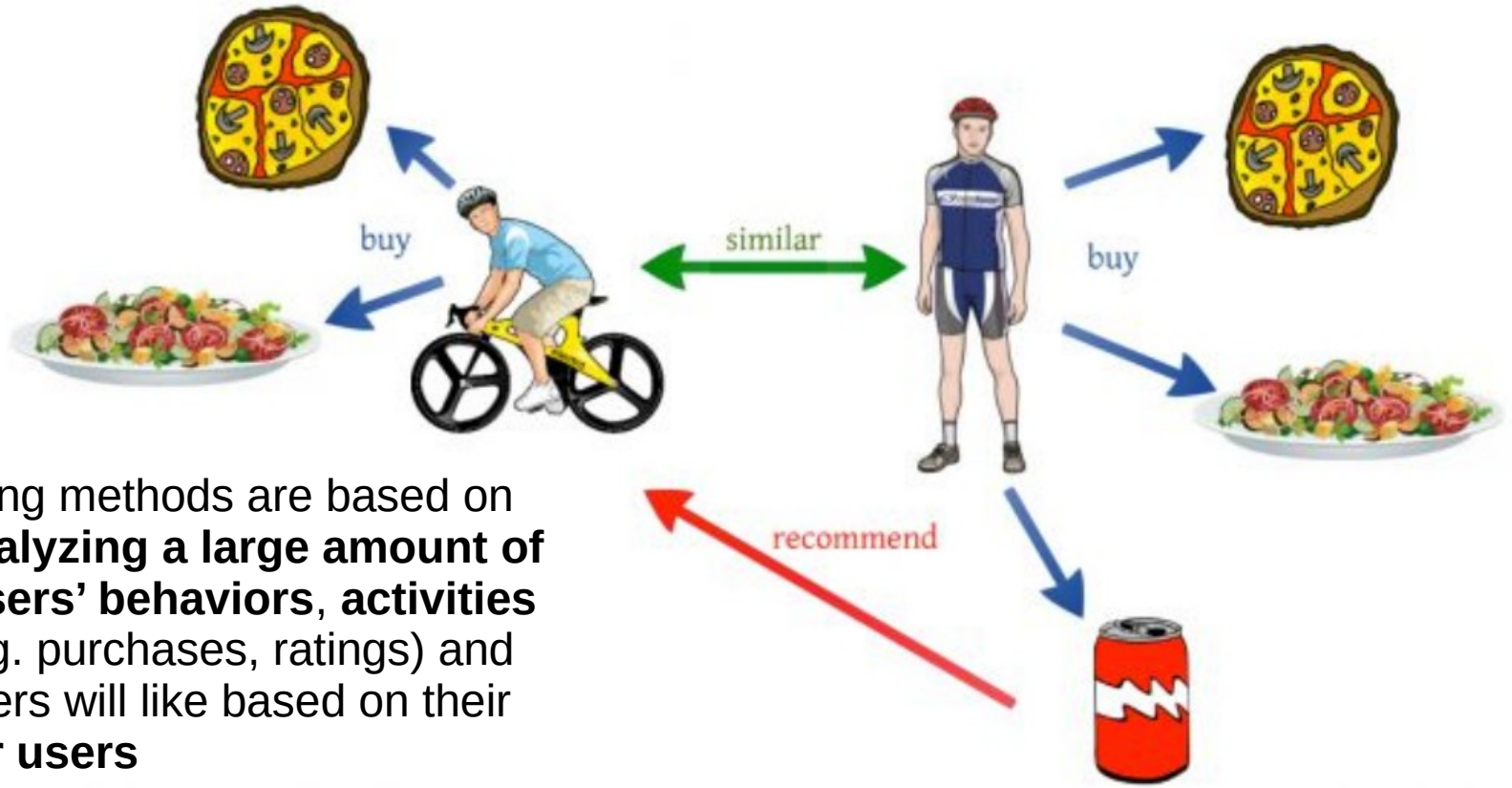
- Based on a **recommendation engine**
- **Mathematical model or objective function** able to **predict** how much a “user will like” an item
  - Predict **rating** or **preference** or ‘**usefulness**’ for a user

- Two main entities involved
  - **Users**
  - **Items**

- **Main approaches (or categories):**
  - *User-based collaborative filtering*
  - *Content-based filtering*
  - *Hybrid Recommendation Sytems*

User-based collaborative filtering



Collaborative filtering methods are based on **collecting and analyzing a large amount of information on users' behaviors**, **activities** or **preferences** (eg. purchases, ratings) and predicting what users will like based on their **similarity to other users**

A **key advantage** of the collaborative filtering approach is that it is capable of accurately recommending complex items such as movies without requiring an "understanding" of the item itself, that may be difficult to achieve

User-based collaborative filtering

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Main steps

Similarity Calculation:

- For a given user (let's call them User A), the system identifies other users who have **similar preferences or behavior**
- **Similarity** is often measured using metrics such as cosine similarity between vectors or Pearson correlation coefficient
- Also user relations could be considered

Item Recommendations:

- Once similar users are identified, the system **recommends** items that those users have liked or interacted with but that User A has not yet experienced

User-based collaborative filtering

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user \ items				
1	2			5
		3		
	4			2
		5		4
	2		4	

A simple version

User-Rating-Matrix (URM)
$R_{u,i}$ is the rating given (or the number of purchases) by user u to item i

- Analyze past user ratings to compute users similarities and predictions
- Assume that users who agreed on the same product in the past will do the same in the future (**similarity between users**)

✓ Simple but good performance

✗ No applicable for new items (cold start problem)

More complex versions can take into account users' relations (eg. network connections) to compute users' similarity

Content-based filtering

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Content-based filtering methods are based on:

- a **description of the items**
- **a profile of the user's**

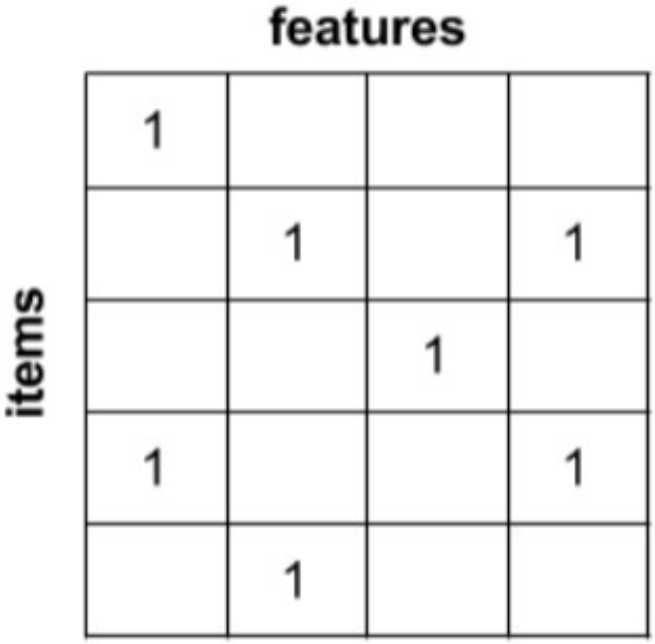
In a content-based recommendation system, **keywords are used to describe the items**

Moreover, a **user profile** is built to indicate the type of item this user likes

Instead of focusing on users, this approach calculates the similarity between items

Each item in the system is represented by a **set of features or attributes, based on which the similarity is calculated → difficult task**

Content-based filtering



Item-Content-Matrix (ICM)
$F_{i,k}$ = 1 if item i has the feature k

- Compute **items similarities**' scores considering item features
- **Basic assumption**: users will like items similar to those they liked in the past

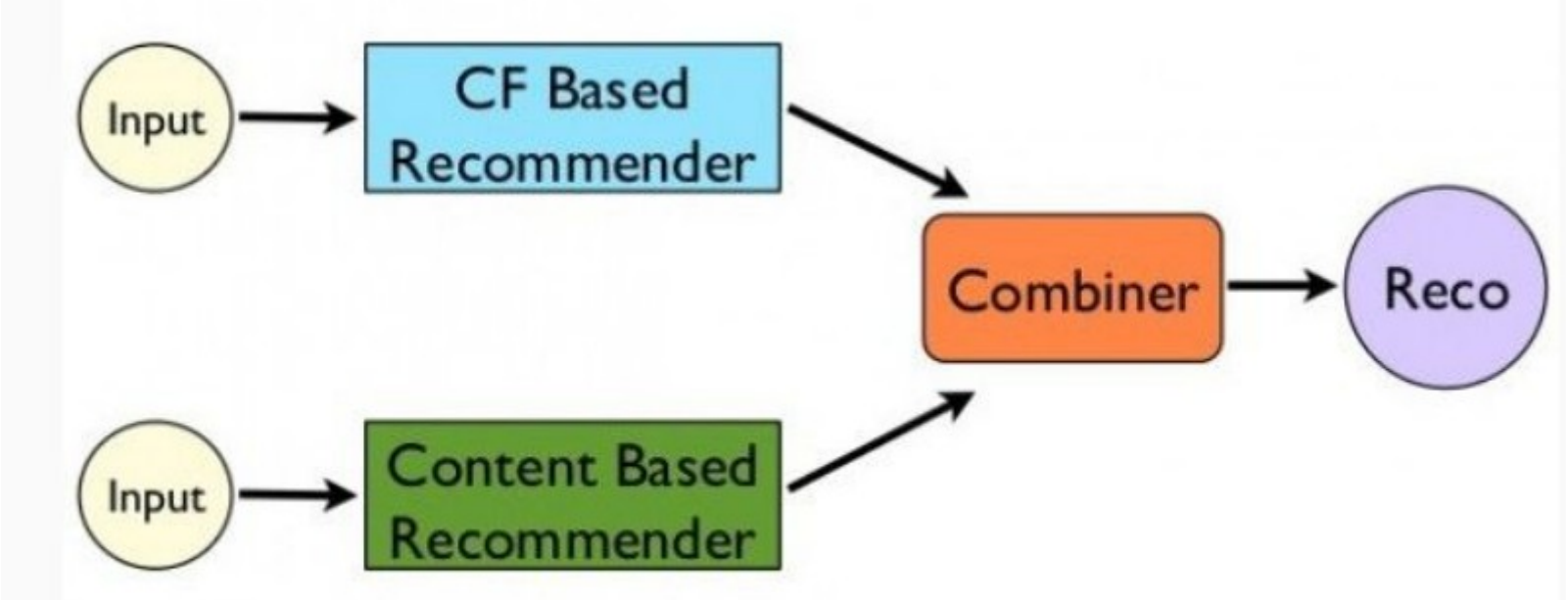
Simplifying assumption: compute similarity based on same purchases / likes from multiple users

Possible variation: this profile is built by aggregating the features of the items the user has shown interest in

✓ No need of item's ratings (eg. It works in a new-item scenario – no cold start problem)

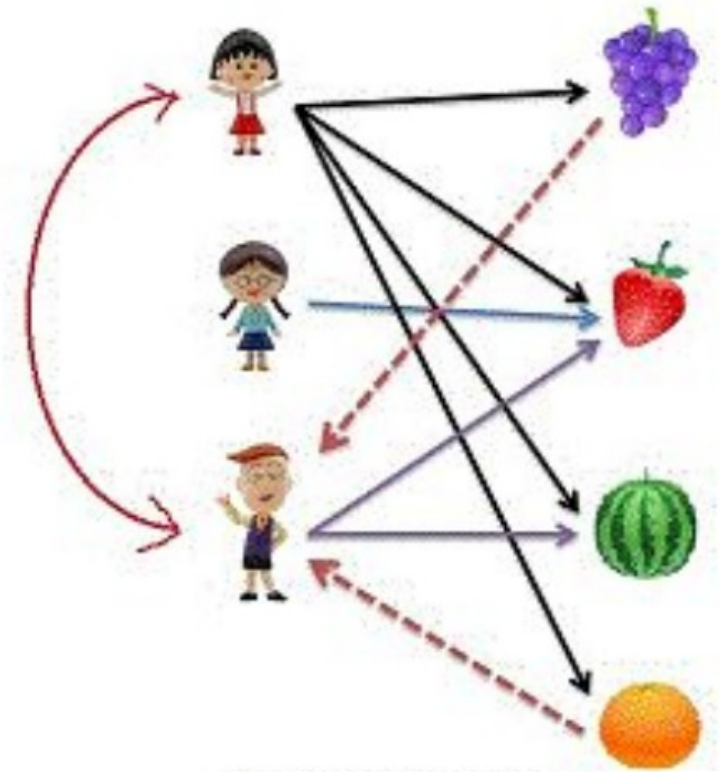
✗ More complex to implement: decision on the features, not all the items have the same feature, ...

Hybrid recommendation system

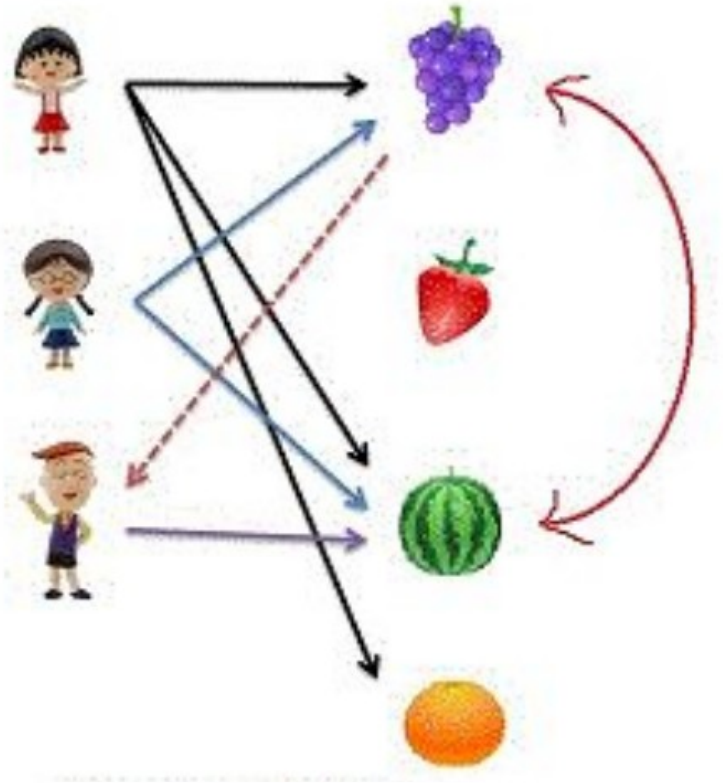


- Hybrid methods can also be used to overcome some of the common problems in recommendation systems such as **cold start**

User-based vs. Content-based



User-based collaborative filtering



Content-based filtering
with simplifying assumption

Complex real systems

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- **The implementation of a recommendation system in a real web site can get very complicated**
- **Some technique:**
  - **Matrix Factorization**: This technique decomposes the user-item interaction matrix into factors to understand hidden patterns, allowing the system to make predictions for missing entries (used by Netflix)
  - **Deep Learning**: Amazon may use neural networks and deep learning models to analyze complex patterns and relationships in user behavior and item attributes.
  - **Session-Based Recommendations**: Taking into account the current user session, Amazon may recommend products based on the user's recent interactions, viewed items, or items in the shopping cart.
  - **Temporal Dynamics**: Recommendations may consider the time factor, adjusting recommendations based on the time of day, day of the week, or seasonal trends.

Complex real systems

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- **The implementation of a recommendation system in a real web site can get very complicated**
- **Some technique:**
  - **A/B Testing**: Amazon likely employs A/B testing to assess the effectiveness of different recommendation algorithms and continuously improve the system
  - A/B testing is a method through which it is possible to test two different versions of the same website (version A and B), or some of its elements (e.g. a landing page, but also titles or layout), sending them to two different user groups. In other words, it is a sort of "experiment" to determine which version works best, based on clear predetermined objectives and Key Performance Indicators (KPIs)

Example

- Let's consider a simple example of a movie recommendation system using a collaborative filtering approach. In collaborative filtering, recommendations are made based on the preferences of users with similar tastes

1) User-Item Matrix:

   Assume we have a matrix where each row represents a user, each column represents a movie, and the matrix entries represent the user's ratings for each movie (e.g., on a scale of 1 to 5).

	Movie A	Movie B	Movie C	Movie D
User 1	4		5	
User 2		3		4
User 3	5	4		3
User 4		5	2	5

Example

2) Similarity Calculation:

Determine the similarity between users based on their movie preferences. Common similarity metrics include cosine similarity or Pearson correlation. For simplicity, let's use cosine similarity.

```
Similarity(User 1, User 2) = 0.36
Similarity(User 1, User 3) = 0.78
Similarity(User 1, User 4) = 0.45
```

3) Recommendation Calculation:

Now, if User 1 wants a movie recommendation, we can calculate a weighted average of the ratings given by similar users, where the weights are the similarity scores

Prediction(User 1, Movie B) = (0.36 * 3 + 0.78 * 4 + 0.45 * 5) / (0.36 + 0.78 + 0.45) ≈ 4.08

This predicts that User 1 might give Movie B a rating of approximately 4.08.

Example

4) Top-N Recommendations:

Provide the top-N recommended movies for User 1 based on the calculated predictions.

```
Top-3 Recommendations for User 1: Movie C, Movie B, Movie A
```

To conclude

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- **To include a recommendation system in your project:**
  - Evaluate which kind of application you are developing
  - Evaluate which information you have available
  - Choose (and motivate) an approach for your recommendation system
  - Apply it to to your system giving some recommendations to users
  - NOTE: a simple ‘algorithm’ is sufficient to implement user-based filtering, but it needs some ranking mechanism!