

## Master on Foundations of Data Science



# Recommender Systems

Non-Personalized Recommender Systems

Santi Seguí | 2022-2023

# What is a **non-personalized** recommender system

A non-personalized recommender system is one that  
**makes the same recommendations for everyone.**

The simplest example is a retailer that shows **the** ten (or some number) **most popular** products on their homepage.

# Several Cases but Two main Approaches

1. Recommenders based on **aggregated opinions** (i.e. ranking)
2. Recommenders based on **basic product associations**

IMDb Charts

## Top Rated Movies

Top 250 as rated by IMDb Users

Showing 250 Titles Sort by: Ranking

Rank & Title	IMDb Rating	Your Rating
1. Cadena perpètua (1994)	★ 9,2	★
2. El padrí (1972)	★ 9,2	★
3. El padrí II (1974)	★ 9,0	★
4. El cavaller fosc (2008)	★ 8,9	★
5. Dotze homes sense pietat (1957)	★ 8,9	★
6. La llista de Schindler (1993)	★ 8,9	★
7. Pulp Fiction (1994)	★ 8,9	★
8. El senyor dels anells: El retorn del rei (2003)	★ 8,9	★
9. El bo, el lleig i el dolent (1966)	★ 8,8	★

SHARE

You Have Seen  
0/250 (0%)  
 Hide titles I've seen

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IMDb Charts

- Box Office
- Most Popular Movies
- Top Rated Movies
- Top Rated English Movies
- Most Popular TV
- Top Rated TV
- Top Rated Indian Movies
- Lowest Rated Movies

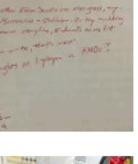
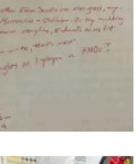
---

Top Rated Movies by Genre

- Action
- Adventure
- Animation
- Biography
- Comedy
- Crime
- Drama
- Family
- Fantasy
- Film-Noir
- History
- Horror
- Music
- Musical
- Mystery
- Romance
- Sci-Fi
- Sport
- Thriller
- War

# News Recommendations

reddit [candents](#) [nous](#) [creixent](#) [polèmic](#) [top](#) [gildejat](#) [wiki](#) [promogut](#)

Rank	Upvotes	Post	Source	Comments
1	8647	 Register for a free ticket to The Artificial Intelligence Conference by MLconf (hello.conference.ai)	promogut per shonburton	14 comentaris comarteix
2	35.2k	 Kellyanne Conway is mad about 'alternative facts' blowup (washingtonpost.com)	enviat fa fa 21 hores per JooofProbst a /r/politics	319 comentaris
3	18.1k	 Hate it when the door is sealed (i.reddit.it)	enviat fa fa 22 hores per safakooze a /r/aww	987 comentaris comarteix
4	59.5k	 Man records heartbreaking video of the first time his own mother forgets who he is. (youtu.be)	enviat fa fa 17 hores per Ihavegoodworkethic a /r/videos	345 comentaris comarteix
5	29.2k	 Turn that frown upside down! (s-media-cache-ak0.pinimg.com)	enviat fa fa 13 hores per thebrokenghost a /r/aww	1605 comentaris comarteix
6	31.7k	 Killer whale lures birds in with dead fish (i.imgur.com)	enviat fa fa 15 hores per XiKiilzziX a /r/WTF	477 comentaris comarteix
7	691	 me_irl (i.reddituploads.com)	enviat fa fa 20 hores per DatDankWeedTho a /r/me_irl	1320 comentaris comarteix
8	48.9k	 Theresa May banned a US rapper from entering Britain, but won't ban Donald Trump (theguardian.com)	enviat fa fa 18 hores per einombre a /r/politics	488 comentaris comarteix
9	47.0k	 I wrote an essay on Skyrim and this is what my professor commented... (i.reddituploads.com)	enviat fa fa 11 hores per Shonenlegend a /r/gaming	60 comentaris comarteix
10	17.6k	 3,000 grams of pure cannabis oil. (imgur.com)	enviat fa fa 18 hores per Xdexter23 a /r/pics	2269 comentaris comarteix
		 Alternative memes Meme (i.reddituploads.com)	enviat fa fa 22 hores per PM_ME_YA_PETS a /r/teenagers	3820 comentaris comarteix

# Top Recommendations



[See more choices](#)

[Lucky Bums Snow Sport Helmet with Fleece Liner](#)  
by Lucky Bums

\$32<sup>93</sup> - \$63<sup>87</sup>

Some sizes/colors are Prime eligible

More Buying Choices  
\$32.93 new (4 offers)  
\$27.99 used (4 offers)

FREE Shipping on eligible orders  
[Show only Lucky Bums items](#)

118



[See Color & Size Options](#)

[Smith Aspect Helmet Mens](#)  
by Smith Optics

\$64<sup>95</sup> - \$120<sup>00</sup>

Some sizes/colors are Prime eligible

More Buying Choices  
\$95.00 new (25 offers)

FREE Shipping on eligible orders  
[Show only Smith Optics items](#)

78



[See more choices](#)

[Giro Sestriere Snow Helmet](#)  
by Giro

\$59<sup>95</sup> - \$212<sup>69</sup>

Some sizes/colors are Prime eligible

More Buying Choices  
\$69.95 new (3 offers)  
\$64.95 used (1 offer)

FREE Shipping on eligible orders  
[Show only Giro items](#)

41



[See more choices](#)

[SUNVP Ski Helmet Ultralight Integrally Warmest Windproof](#)  
Snowboards Snow Sports Helmet Unisex Adult  
by SUNVP

\$36<sup>99</sup> \$110.09

Some sizes/colors are Prime eligible

FREE Shipping on eligible orders

[Show only SUNVP items](#)

12



[See more choices](#)

[Smith Optics SO-H15AS Men's Aspect Snow Helmet, Matte](#)  
Charcoal-Large

by Smith

\$99<sup>95</sup>

More Buying Choices

\$99.95 new (2 offers)

FREE Shipping on eligible orders

[Show only Smith items](#)

4



[See more choices](#)

[Giro Seam Snow Helmet](#)  
by Giro

\$69<sup>99</sup> - \$338<sup>22</sup>

Some sizes/colors are Prime eligible

More Buying Choices

\$159.94 new (20 offers)

[Show only Giro items](#)

118

Sponsored ⓘ

[Giro Seam Snow Helmet - Men's M...](#)  
\$159<sup>95</sup>   
 118

[Smith Optics Unisex Adult Vantag...](#)  
\$270<sup>00</sup>   
 51

[SUNVP Ski Helmet Ultralight Integr...](#)  
\$36<sup>99</sup> \$110.09   
 12

[Giro Sestriere Snow Helmet \(Black...](#)  
\$69<sup>95</sup> \$70.00   
 41

# Product Association



## Lucky Bums Snow Sport Helmet

by [Lucky Bums](#)

788 customer reviews | 69 answered questions

Price: [\\$30.59 - \\$65.88](#)

Size:

Select ▾

Color: Kryptek Typhon, Glossy



- ALL-AROUND PROTECTION FOR ALL SNOW SPORTS NEEDS - The Lucky Bums Snow Sports Helmet is everything you want in a helmet at an affordable price: it's comfortable, stylish, durable, and most of all, functional. It features two protective layers, a padded chin strap, and goggle loop for extreme downhills. Ready to go right out of the box, find your size and color today.
- ABS AND EPS CONSTRUCTION THAT MEETS EN1077 STANDARDS - This helmet has two reinforced layers. The external cap is made from strong ABS material, which is covered by a supporting EPS outer shell for dual protection. This helmet fully complies with EN1077 standards and is CE certified.
- NUMEROUS FEATURES FOR A FULL AND ENJOYABLE DAY ON THE SLOPES - There's more than meets the eyes with the Lucky Bums Snow Sports Helmet. Inside, the internal fabric lining and ear padding include a hypoallergenic and antibacterial treatment while the ESP inner shell features multiport with mesh screens to prevent snow buildup and allow for ample airflow.
- COMFORTABLE WITH ADJUSTABLE FIT AND MULTIPLE SIZING OPTIONS - In addition to being vented and hypoallergenic, this helmet is comfortable to wear all day long. Its padded chin strap and integrated goggle loop enhance comfort and function. There are 4 sizes to choose from and each helmet includes a micro adjustable strap for the perfect fit for just about anyone.
- DURABLE AND DEPENDABLE WITH MANUFACTURER'S LIMITED LIFETIME WARRANTY - We know how upsetting it is to have a great day on the mountain spoiled by seemly, uncomfortable, and undependable gear. That's why we created Lucky Bums. We believe in our quality and put our money where our mouth is. Each helmet comes with Manufacturer's Limited Lifetime Warranty, which protects against defects in materials or workmanship. Look good, feel good, be protected.

## Customers Who Bought This Item Also Bought

Page 1 of 10



Bole Mojo Snow Goggles  
 1,560  
\$11.69 - \$62.77

Ski Goggles, 2-Pack Skate Glasses for Kids, Boys & Girls, Youth, Men & Women, with UV 400...  
 114  
#1 Best Seller in Snowboarding Equipment  
\$11.99

Lucky Bums Snow Sport Helmet with Fleece Liner  
 118  
\$32.93 - \$63.87

Lucky Bums Kid's Alpine Series Doodlebug Helmet  
 14  
\$34.99 - \$79.99

OutdoorMaster Ski Goggles PRO - Frameless, Interchangeable Lens Snow Goggles for Men &...  
 417  
\$24.99 - \$49.99

Bole Carve Snow Goggles  
 492  
\$17.49 - \$102.94

Traverse Dirus 2-in-1 Convertible Ski & Snowboard/Bike & Skate Helmet  
 78  
#1 Best Seller in Adult Bike Helmets  
\$39.98 - \$40.00

OutdoorMaster OTG Ski Goggles - Over Glasses Ski / Snowboard Goggles for Men, Women & Youth...  
 295  
#1 Best Seller in Adult Bike Helmets  
\$19.99 - \$25.99

Arctix Men's SnowSports Cargo Pants  
 1,537  
#1 Best Seller in Men's Snowboarding Clothing  
\$26.95 - \$84.74

SUNVP Ski Helmet Upscale Warmest Windproof Adult Integrally Snow Sports Snowboard...  
 12  
\$42.99



Browse ▾

DVD

Search



Joshua ▾

## Top Picks for Joshua



## Trending Now



## Because you watched Narcos



## New Releases



# Recommenders based on aggregated opinions



## How to rank?

To rank the items:

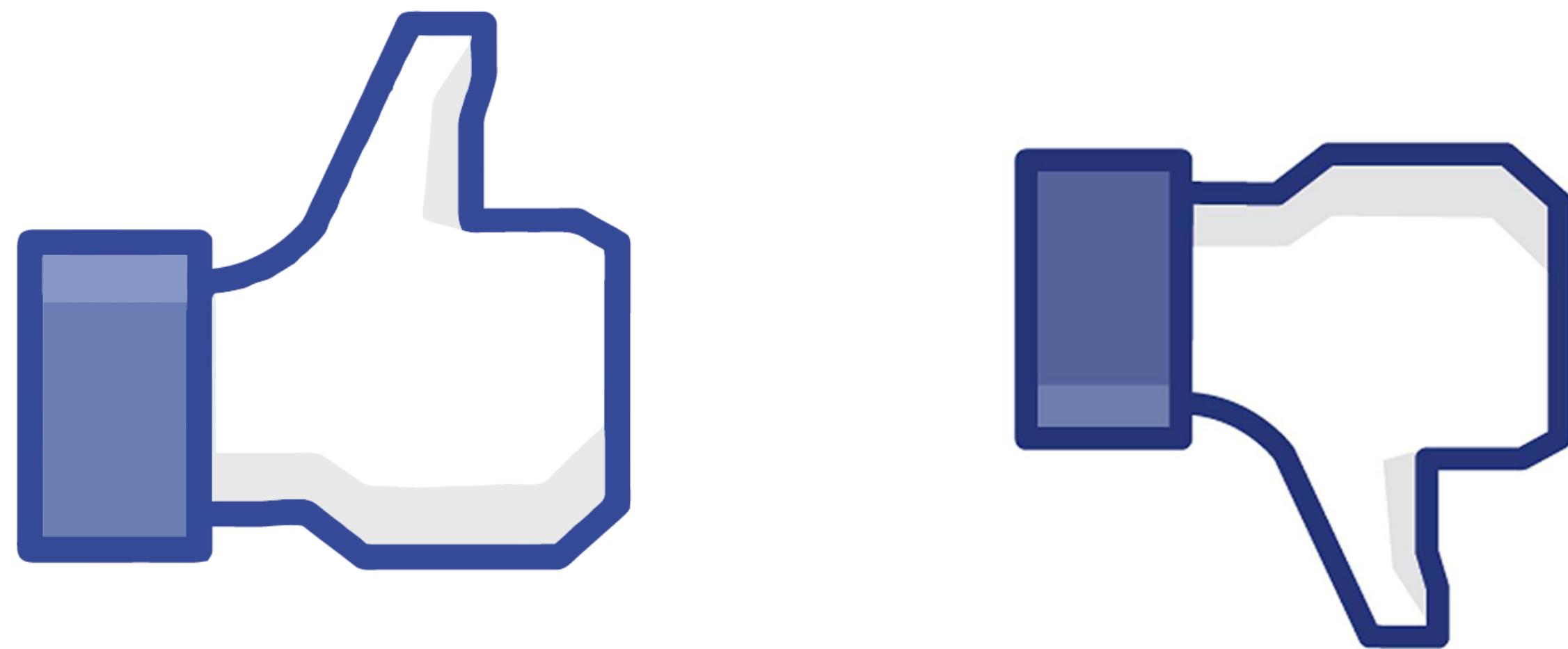
# Which data are we gonna use?





**Widely used**

How many stars? 3 - 5 - 7 - 10 ?



Vote up/down

Like (+1)

# How to score/rank items:

- We first have to **understand the business case**. Several factors plays a role.
- Which **information do we have** about the items?
  - Bought / Seen / Rated / ...
  - From how many users do we have the info?
  - How old is that info?

# Considerations



- Confidence
  - How confident are we that this item is good?
- Risk tolerance
  - High-risk, high-reward
  - Conservative recommendations
- Domain and business considerations
  - Age
  - System goals



**How the ranking  
works?**



# How the ranking works?

**quality**, **recency** and **quantity** of reviews.



**How the ranking  
works?**



## The vote average for film or TV show "X" is clearly wrong! Why are you displaying another rating?

IMDb displays **weighted** vote averages rather than raw data averages. Various filters are applied to the raw data in order to eliminate and reduce attempts at "vote stuffing" by individuals more interested in changing the current rating of a movie or TV show than giving their true opinion of it.

Although the raw mean and median are shown under the detailed vote breakdown graph on the ratings pages, the user rating vote displayed on a film / show's page is a weighted average. In order to avoid leaving the scheme open to abuse, we do not disclose the exact methods used.

We can provide some more detail here to reassure you that our methods are both sound and fair. First of all, the same formula is applied universally across the database to all movies and shows without exception so there is no bias in when and where the scheme operates. Occasionally we receive mail from people who seem to assume that some favorite movie or show has been victimized by the weighted ratings whereas this is not the case. The objective of the scheme is to present a more representative rating which is immune from abuse by subsets of individuals who have combined together with the aim of influencing (either up or down) the ratings of specific movies or shows. This includes people involved in the production of a movie / TV show and their friends or fans trying to unduly raise the rating far above that of where the typical IMDb users would rate it.

The scheme combines a number of well-known and proven statistical methods, including a trimmed mean to reduce extreme influences and, most importantly a complex voter weighting system to make sure that the final rating is representative of the general voting population and not subject to over influence from individuals who are not regular participants in the poll. The scheme has been developed internally over the 25 years which the poll has been in operation and tuned on a regular basis to make sure it remains fair.

Most of the feedback we receive about our votes is based on the incorrect assumption that all votes cast by our users have the same impact on the final rating. This is not the case. Different votes may have different **weight** when they're used to calculate the final weighted rating. Most people think of the *arithmetic mean* when they hear the word *average*. When calculating an arithmetic mean, all votes are treated equally: the average is the sum of all the votes divided by the number of votes.

A weighted average, however, is defined as "an average that takes into account the proportional relevance of each component, rather than treating each component equally". There's nothing arcane or mysterious about it: it's a very simple, universally accepted statistical method, commonly used in a wide variety of fields (from financial analysis to student reports).

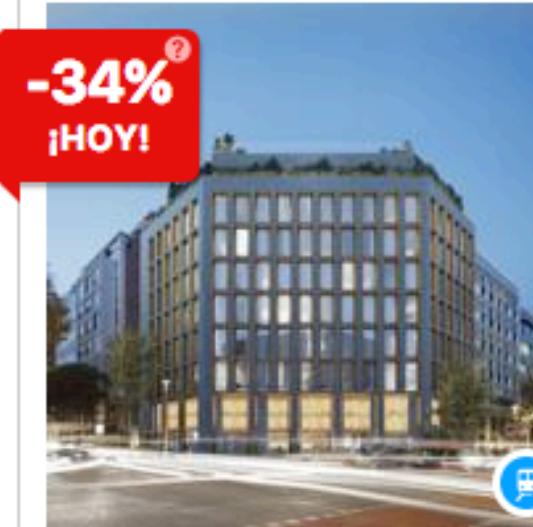
For example, an automobile magazine reviewing a new car may give it high marks in several categories (appearance, comfort, fuel efficiency, price, number of cup holders). However a model with high ratings in all those categories may still get a low overall score if it gets a low vote in just one or two other areas (like speed or safety): even the cheapest, nicest-looking and most fuel-efficient car isn't worth buying if the fuel tank explodes when you hit the brakes or if its top speed is only 15 miles per hour. Clearly, a high (or low) vote in some categories has more **weight** than the same exact vote cast in another category, so the final rating takes these differences into account.

Our calculations follow a similar principle: some votes have more weight than others. We will **not** disclose exactly if/when/how certain votes are weighted differently because the idea is, among other things, to give a more objective rating and neutralize attempts to artificially inflate or deflate the average user rating on a film or show.

We're confident that our system provides a reasonably faithful representation of our users' opinions. This scheme is applied uniformly to all films listed in the database, without exception; and since it has proved to be very effective we do not plan to abandon it, though we periodically revisit and tweak it to make it even more accurate and tamper-proof.



# How the ranking works?



**-34%<sup>?</sup>  
¡HOY!**

**The One Barcelona GL ★★★★☆**   
[Eixample, Barcelona](#) – Cerca del metro

Hay 8 personas mirando en este momento  
Reservado 157 veces esta semana

 Piscina al aire libre  Spa y centro de bienestar

 Tiene 1 restaurante

 Habitación Doble - 1 o 2 camas  
Puedes cancelar más tarde.  
Aprovecha y consigue un buen precio hoy.

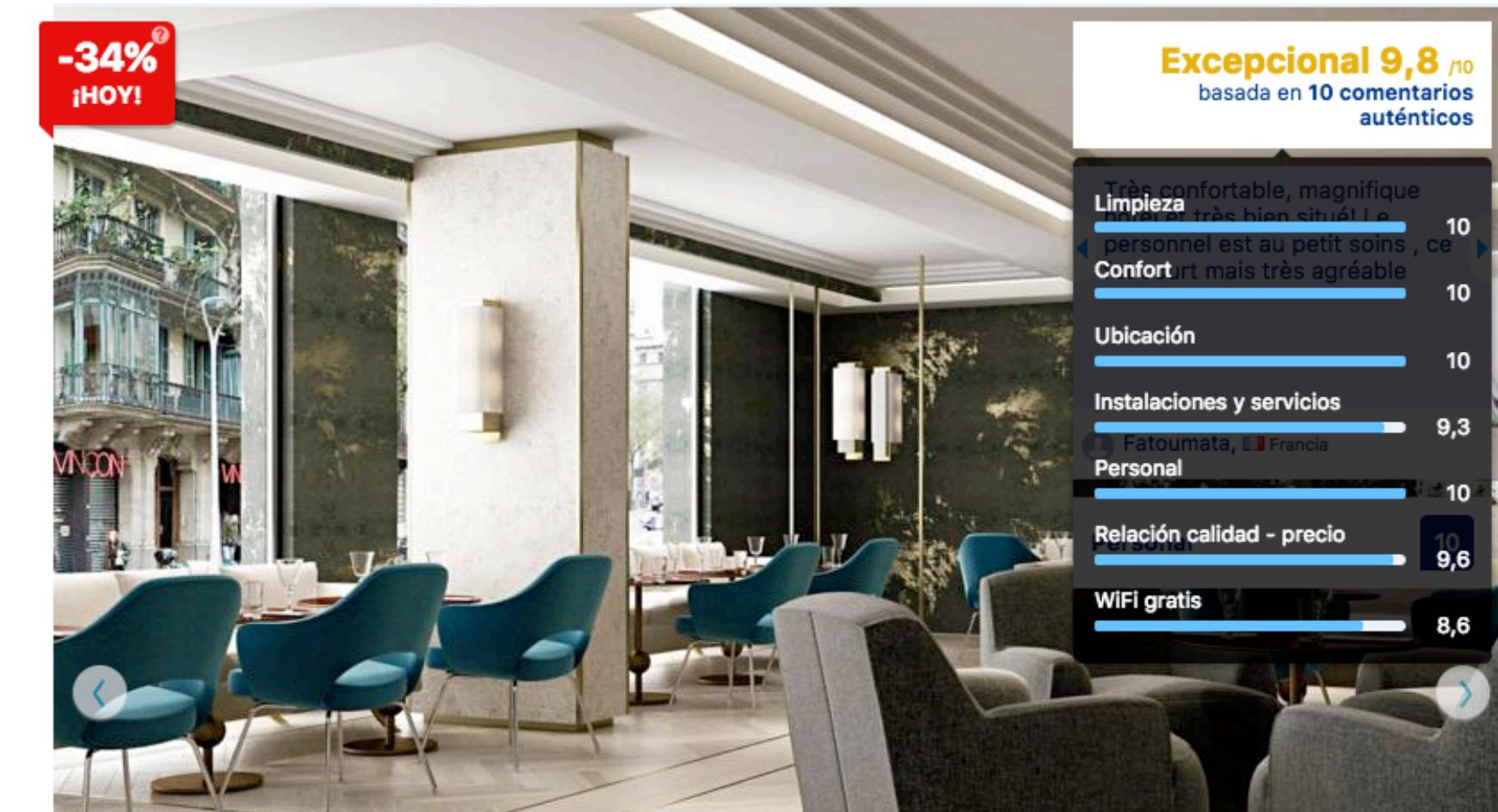
**Excepcional 9,8**  
**Ubicación 10,0**  
– según  
10 comentarios

**Precio para 2 noches**  
**Muy solicitado. ¡Solo quedan 2 habitaciones en nuestra página!**  
**-34% € 560 **  
**€ 367**  
**Cancelación GRATIS.**  
**Sin pago por adelantado.**

**Ver las 8 habitaciones disponibles >**

# Booking.com

## How the ranking works?



# Booking.com

If it was known everyone  
would try to hack it!



# Booking.com

The way we present properties **needs to be relevant**. We aim to **match the right product**, with the **right person**, at the **right time**. Therefore, ranking is a complex and **scientific approach to optimizing this for both partners and customers**.

Our goal is to give customers **suggestions of properties that will make them happy**, therefore driving the right customers and high-quality traffic to partners. **When partners and guests are well matched and proper expectations are set, this leads to higher conversion**.

## What is included in ranking?

There are many different factors and elements that influence ranking. This includes data from partners and customers, **ranging from click and booking behavior to conversion, availability and pricing data**, as well as the **facilities of a property**. Ranking, therefore, isn't just dependent on one thing.

Basically, anything we know about our customers and partners is factored into how our search results are ordered on Booking.com.

Millions visit Booking.com every day and we want to make your property stand out as much as possible. Every customer and accommodation partner is unique, so our dedicated team is here to make sure that your property appeals to the right audience.

## How do you influence visibility?

We have various tools to help you get the most out of your Booking.com page. But first, make sure you have all the basics set up, so you can grow organically.

We offer personalized advice based on 4 specific areas: [pricing](#), [availability](#), [content](#), and [extra features](#). All of these create a complete profile so we can match you with the right audience.

Through continued improvement of these topics, plus a good guest review score, you'll help your property get a higher position in search results – making it stand out to more bookers looking for your accommodation type.

A higher ranking position **will help lead to more bookings, fewer cancellations, and more satisfied guests**.

# Booking.com

How do I get better visibility on Booking.com?

How you appear in search results is a very dynamic process that takes the millions of searches each day—with their own individual needs—and matches them to the best property based on their criteria. We know our customers. Whether they're family travelers, business travelers, budget travelers, or city lovers, we cater to all and will use our knowledge to match you well for a great experience. We have more info on [how ranking works](#) on Booking.com to explain it all.

**Do you want to appear higher in search results on Booking.com? Here are a few tips:**

## **High property page score:**

First impressions matter, so making sure you give bookers all the info they expect can bring more bookings since they understand what exactly is offered.

## **Pricing:**

Keep your rates competitive and attract more bookers. A recent TripAdvisor study showed that price is a key factor in 95% of bookings. Learn more about rates in your area with [RateIntelligence](#).

## **Availability:**

Don't miss out on potential new bookings. By making sure you're constantly bookable on Booking.com, you'll help improve your ranking. Remember to always show rates for high-demand dates. [Learn why availability is important with this video](#).

## **Photos:**

Customers are always attracted to properties with great, high-resolution photos. You can check the size of your photos, as well as add and remove images, by checking the [Property tab](#). [Check out this photography guide](#).

## **Extra features:**

We have a large selection of additional features that can help attract more reservations. You can pick from options like web marketing or setting up last-minute reservations without credit card details. These types of additions can help improve your visibility on the site.

## **Partner programs:**

There are other opportunities available, like becoming a [Preferred Partner](#) (if eligible) or using the [Visibility Booster](#) to improve ranking as well.

## **Growing organically:**

It's important to keep the very basics in mind. Read more in [How do I increase visibility organically?](#)



## How to crack the Booking.com algorithm

[Comment](#) [Print](#)

Dec 18.2014

If we want to improve our positioning on [Booking.com](#) as rapidly as possible in order to increase sales, it is obvious what needs to be done.

Increase commissions!

This maximizes the profits of Booking.com and in turn its web algorithm will reward us with good search results.

**NB:** This is an analysis by Francesco Canzoniere, ex-CEO of [Viajar](#) and now founder and managing director of [Travel Performance](#).

But do increases in commissions have consequences? Yes, of course.

Just as when hotels go headlong into a price war (downwards), the same happens when they enter into a commission war, they all end up with the same market share, but with lower net income.

At times It is possible that the hotel feels obliged to pay higher commissions but it is also clear in many cases that this solution is chosen for its "speed and simplicity".

But is it sustainable to continue working with a strategy of "get some work and [monetize it"?](#)

# MovieLens

GroupLens Research has collected and made available rating data sets from the MovieLens web site (<http://movielens.org>). The data sets were collected over various periods of time, depending on the size of the set. Before using these data sets, please review their README files for the usage licenses and other details.

**Help our research lab:** Please [take a short survey](#) about the MovieLens datasets

**Seeking permission?** If you are interested in obtaining permission to use MovieLens datasets, please first read the terms of use that are included in the README file. Then, [contact us](#), including a description of how you will (a) use the datasets, (b) redistribute the datasets, and (c) provide attribution. We typically do not permit public redistribution (see [Kaggle](#) for an alternative download location if you are concerned about availability).

## recommended for new research

### MovieLens 25M Dataset

MovieLens 25M movie ratings. Stable benchmark dataset. 25 million ratings and one million tag applications applied to 62,000 movies by 162,000 users. Includes tag genome data with 15 million relevance scores across 1,129 tags.  
Released 12/2019

- [README.txt](#)
- [ml-25m.zip](#) (size: 250 MB, [checksum](#))

Permalink: <https://grouplens.org/datasets/movielens/25m/>

# Datasets

[MovieLens](#)

[WikiLens](#)

[Book-Crossing](#)

[Jester](#)

[EachMovie](#)

[HetRec 2011](#)

[Serendipity 2018](#)

[Personality 2018](#)

[Learning from Sets of Items  
2019](#)

# Hands on time!



<https://github.com/ssegui/recsysMaster2020>

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2019](#)

# Damped means

- Problem: **There is low confidence with few ratings**
- Solution: **Assume that, without evidence, everything is average**
- Ratings are evidence of non-averageness
- $k$  controls strength of evidence required

$$damped\_mean = \frac{\sum_u r_{u,i} + k\mu}{n + k}$$

# Confidence Intervals

- From the reading: lower bound os statistical confidence interval
- Choice of bound affects risk/confidence
  - Lower bound is conservative: be sure it's good
  - Upper bound is risky: there's a chance of amazing

# Domain Considerations: Time



old stories are not interesting, even if they have many upvotes!



items have short lifetimes

# Case 1: News Recommendations

reddit [cidents](#) [nous](#) [creixent](#) [polèmic](#) [top](#) [gildejat](#) [wiki](#) [promogut](#)

1 ↑ 14 ↓  Register for a free ticket to The Artificial Intelligence Conference by MLconf [\(hello.conference.ai\)](http://hello.conference.ai)  
promogut per shonburton  
1 promogut 5 comentaris comparteix

2 8647 ↑ ↓ Kellyanne Conway is mad about 'alternative facts' blowup [\(washingtonpost.com\)](http://washingtonpost.com)  
enviat fa fa 21 hores per JoofProbst a /r/politics  
987 comentaris comparteix

3 35.2k ↑ ↓ Hate it when the door is sealed [\(i.reddit.it\)](http://i.reddit.it)  
enviat fa fa 22 hores per safakooze a /r/aww  
345 comentaris comparteix

4 18.1k ↑ ↓ Man records heartbreaking video of the first time his own mother forgets who he is. [\(youtu.be\)](http://youtu.be)  
enviat fa fa 17 hores per Ihavegoodworkethic a /r/videos  
Episode #6  
1605 comentaris comparteix

5 59.5k ↑ ↓ Turn that frown upside down! [\(s-media-cache-ak0.pinimg.com\)](http://s-media-cache-ak0.pinimg.com)  
enviat fa fa 13 hores per thebrokenghost a /r/aww  
477 comentaris comparteix

6 29.2k ↑ ↓ Killer whale lures birds in with dead fish [\(i.imgur.com\)](http://i.imgur.com)  
enviat fa fa 15 hores per XIKillzzIX a /r/WTF  
1320 comentaris comparteix

7 31.7k ↑ ↓ me\_irl [\(i.reddituploads.com\)](http://i.reddituploads.com)  
enviat fa fa 20 hores per DatDankWeedTho a /r/me\_irl  
For every update this post gets I'll scream louder from the Bee movie until at my friend's house.  
488 comentaris comparteix

8 691 ↑ ↓ Theresa May banned a US rapper from entering Britain, but won't ban Donald Trump [\(theguardian.com\)](http://theguardian.com)  
enviat fa fa 18 hores per elnombre a /r/politics  
60 comentaris comparteix

9 48.9k ↑ ↓ I wrote an essay on Skyrim and this is what my professor commented... [\(i.reddituploads.com\)](http://i.reddituploads.com)  
enviat fa fa 11 hores per Shonenlegend a /r/gaming  
2269 comentaris comparteix

10 47.0k ↑ ↓ 3,000 grams of pure cannabis oil. [\(imgur.com\)](http://imgur.com)  
enviat fa fa 18 hores per Xdexter23 a /r/pics  
3820 comentaris comparteix

11 17.6k ↑ ↓ Alternative memes [Meme](#) [\(i.reddituploads.com\)](http://i.reddituploads.com)  
enviat fa fa 22 hores per PM\_ME\_YA\_PETS a /r/teenagers  
174 comentaris comparteix

# How to score **NEW** stories

$$\frac{(U - D - 1)^\alpha}{(t_{now} - t_{post})^\gamma} \times P$$

- where  $U$  is up-votes,  $D$  is down-votes and  $t_{now} - t_{post}$  is the age of the new.  $P$  is a penalty term related to the new. Where  $\alpha$  and  $\gamma$ , are a decay polynomial parameter and the gravity parameter
- Net up-votes, polynomially decayed by time

# How to score **NEW** stories

$$\log_{10} \max(1, |U - D|) + \frac{\text{sign}(U - D)t_{post}}{45000}$$

- Log term applied to votes
  - decrease marginal value of later votes
- A 1000-vote item is better than a 100-vote item. But is a 2000-vote item that much better yet?

# Difficulties with Rating



# Difficulties with Rating

- The most simple approaches
  - Average rating / Up-vote proportion
    - Does not show popularity
    - # of people who vote, do they like it?
  - # Up-vote / # of likes
    - Shows popularity
    - No controversy
  - %  $\geq 4$  stars
  - Full distribution
    - Complicated

Popularity and  
controversy are important

# Difficulties with Rating

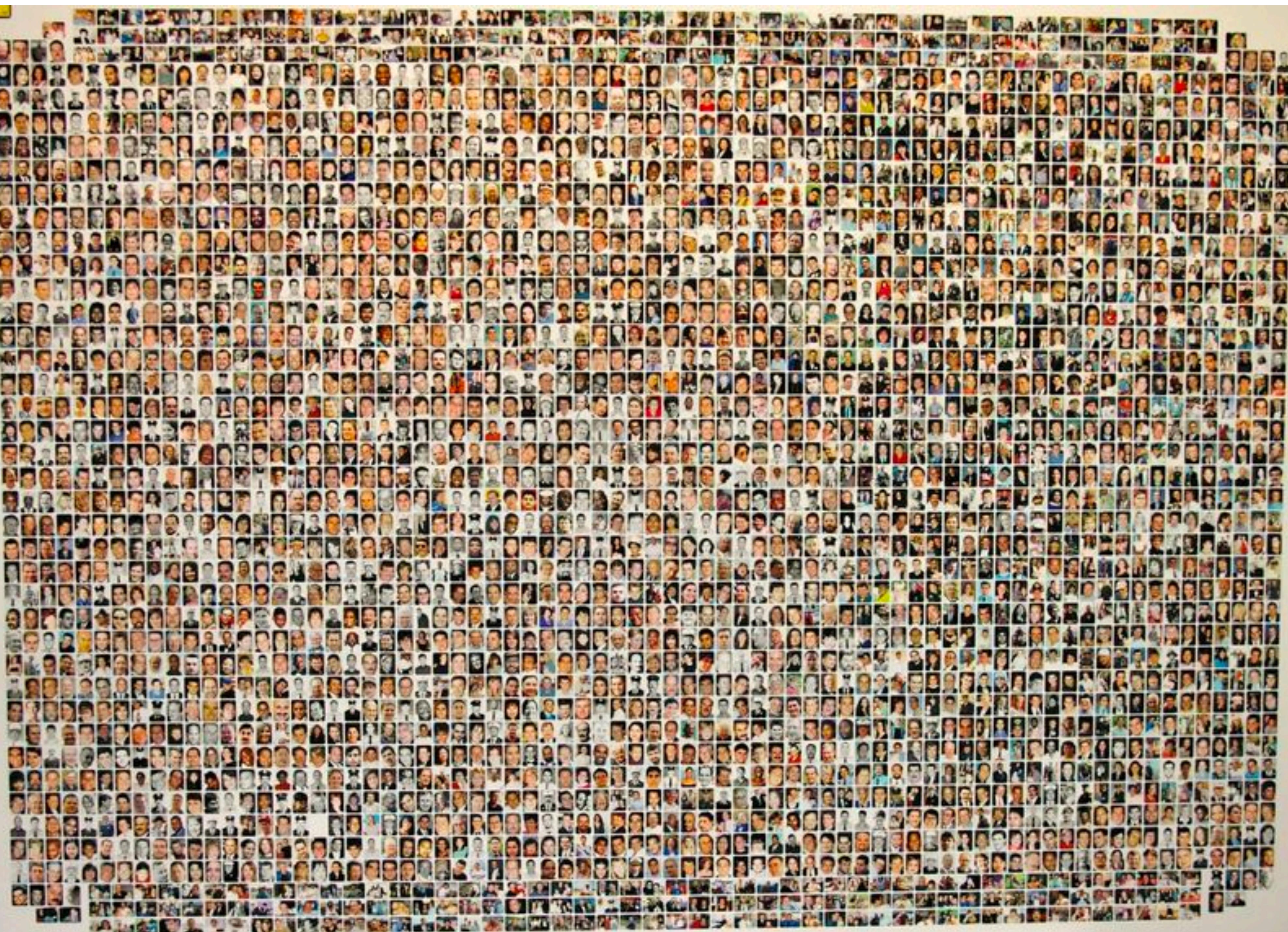
- Are ratings reliable and accurate?
- Do the users change his/her preferences?

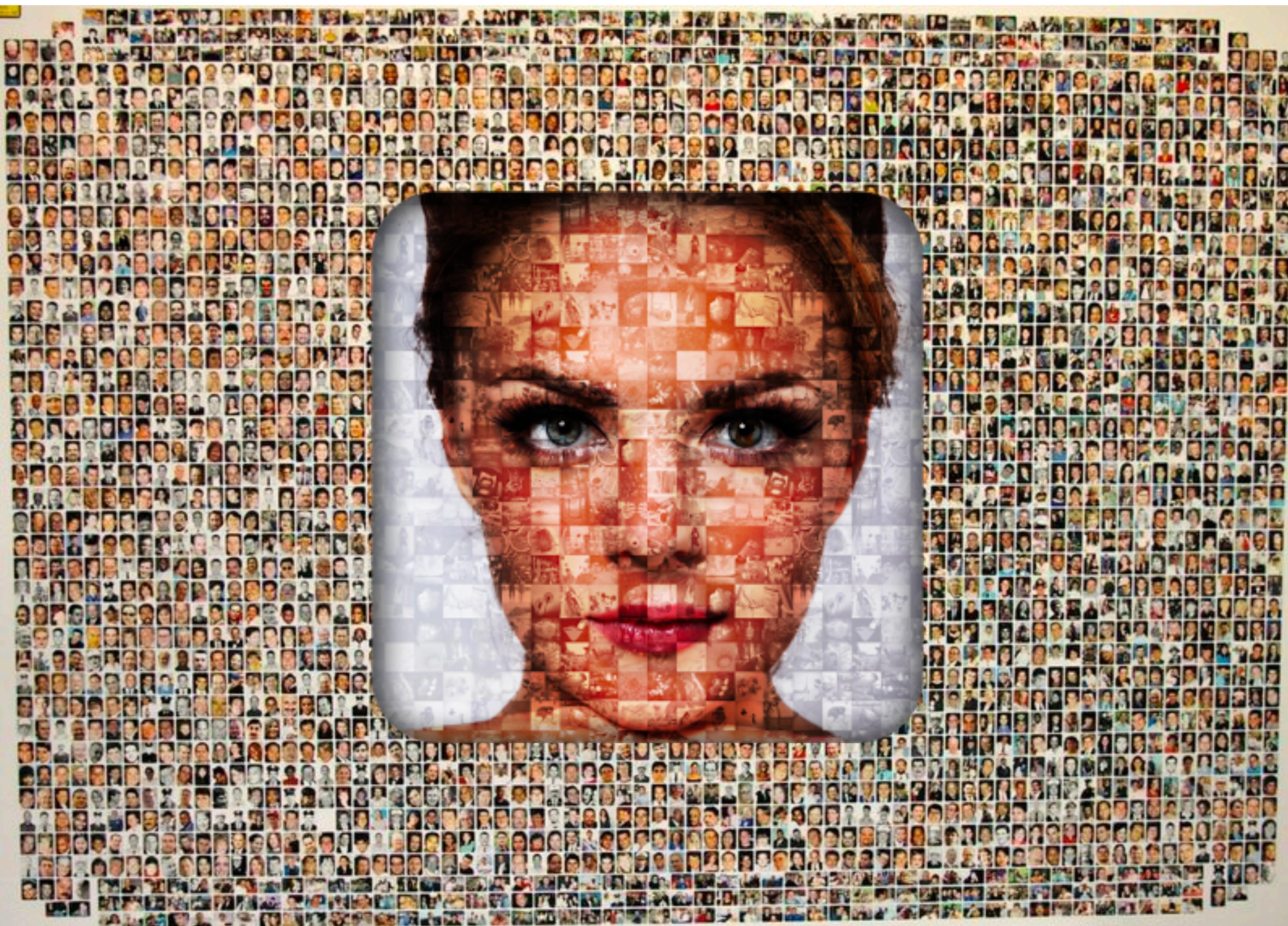
# Predict with **sophisticated score function?**

- Theoretically it is a fine thing to do.
- Be careful with transparency
  - If you say "average rating" and shows damped mean, users can be confused

# Difficulties with Rating

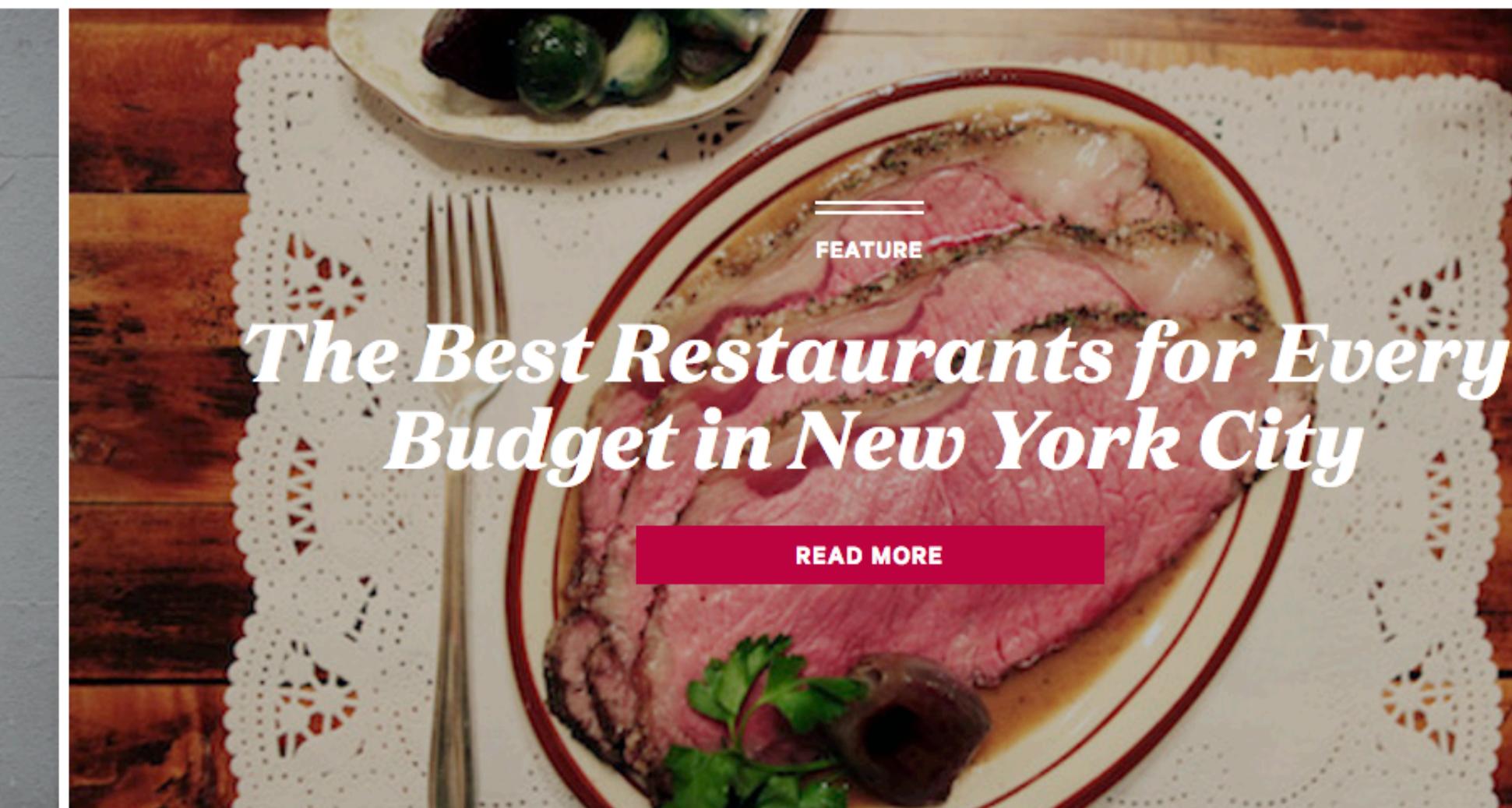
- What is a mean rating?





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OVERALL



PIZZA



STEAKHOUSE



BURGER



FRENCH



SEAFOOD



CHINESE



ITALIAN



MEXICAN



# Why?

# Your opinion diverges with the community averages

# To overcome these difficulties

on



See more choices

Lucky Bums Snow Sport Helmet with Fleece Liner

by Lucky Bums

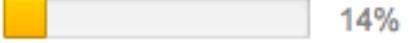
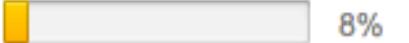
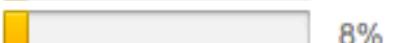
\$32<sup>93</sup> - \$63<sup>87</sup>  Some sizes/colors are Prime eligible

More Buying Choices  
\$32.93 new (4 offers)  
\$27.99 used (4 offers)

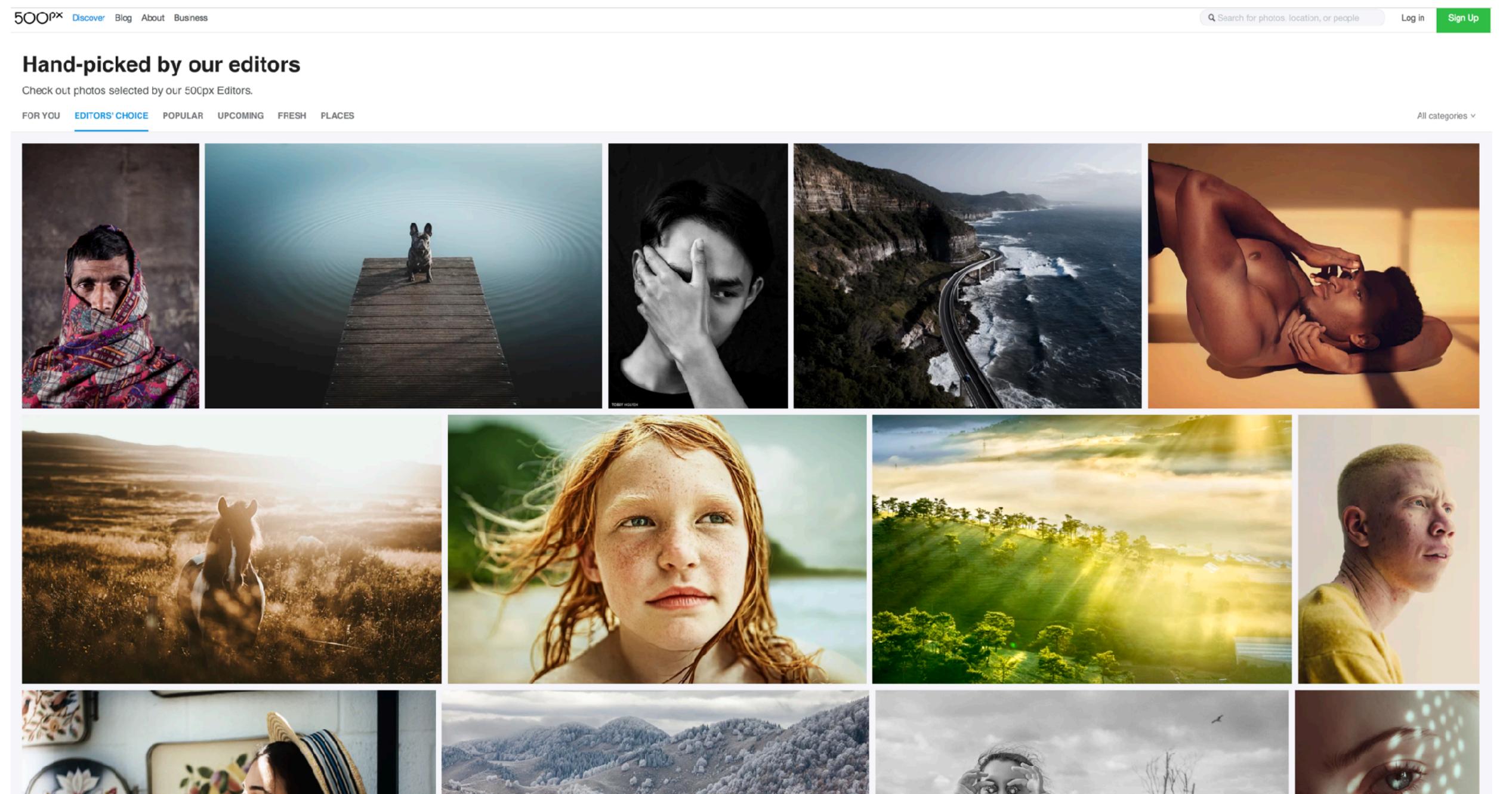
FREE Shipping on eligible orders

Show only Lucky Bums items

 118

4.2 out of 5 stars	
5 star	 62%
4 star	 14%
3 star	 8%
2 star	 8%
1 star	 8%

See all verified purchase reviews ▾



People who buy **X** also  
buy **Y**..

## Product association recommenders

# Market Basket Problem



# Example

- 1 ['citrus fruit', 'semi-finished bread', 'margarine', 'ready soups']
- 2 ['tropical fruit', 'yogurt', 'coffee']
- 3 ['whole milk']
- 4 ['pip fruit', 'yogurt', 'cream cheese ', 'meat spreads']
- 5 ['whole milk', 'butter', 'yogurt', 'rice', 'abrasive cleaner']
- 6 ['rolls/buns']
- 7 ['other vegetables', 'UHT-milk', 'rolls/buns', 'bottled beer', 'liquor (appetizer)']
- 8 ....

# People who buy X also buy Y..

- How can we do this? How is our dataset (or a typical one) ?
  - User profiles?
  - Transaction data (people who bought them at the same time)?
  - User profile but time-constrained?

# Terms

- “IF” part = **Antecedent**
- “THEN” part = **Consequent**
- “Item set” = the items (e.g., products) comprising the antecedent or consequent
- **Antecedent** and **consequent** are *disjoint* (i.e., have no items in common)

# How to score the association rule?

- Percentage of **X**-buyers who also bought **Y**

$$\frac{\mathbf{X} \text{ and } \mathbf{Y}}{\mathbf{X}}$$

**Hands on time!**

# Hands on time!



# How to score?

- Percentage of X-buyers who also bought Y

$$\frac{\text{X and Y}}{\text{X}}$$

**Hands on time!**

- What happens? Is it a good measure?
  - What happens with very popular items?

# Solving <<*Bananas*>> Problems

# How to score

- Let's adjust by looking at whether X makes more likely than not X ( $\text{!}X$ )

$$\begin{array}{c} \mathbf{X \text{ and } Y} \\ \hline \mathbf{X} \\ \hline \mathbf{\text{!}X \text{ and } Y} \\ \hline \mathbf{\text{!}X} \end{array}$$

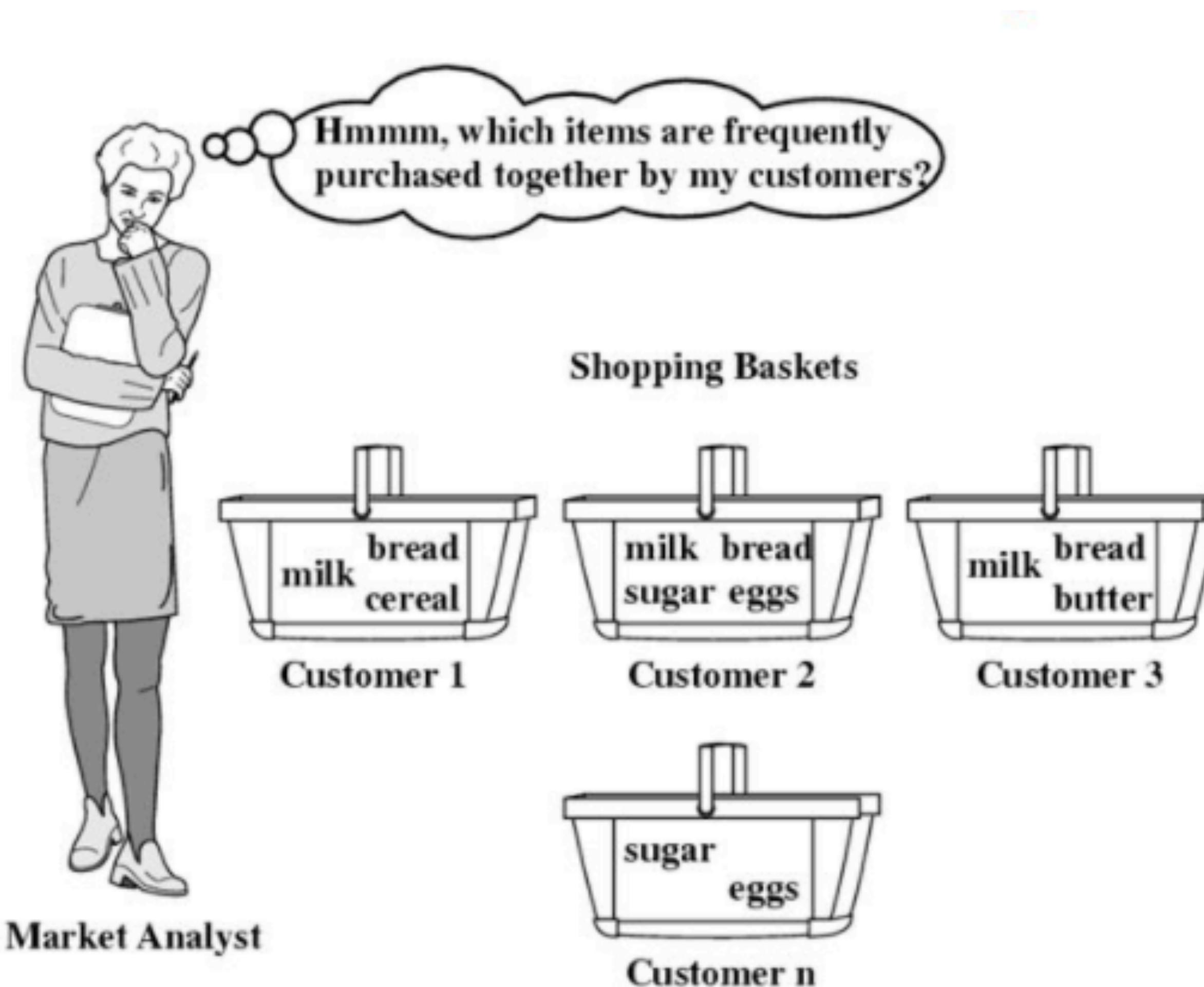
- It focuses on how Y increases buying X
- Value higher than one says that is more probable to be bought X when Y is bought than not.

# How to score

- Association rule mining

$$\frac{P(\mathbf{X} \text{ and } \mathbf{Y})}{P(\mathbf{X}) P(\mathbf{Y})}$$

Things can be more complex: We can have several items in our *basket case*



# Association Rules

## Terminologies:

items : 1, 2, 3,....

itemSet: {1},{1,2},{1,4,2,5},...

1-itemset: {1},{2},{3}

2-itemset: {1,2},{2,3},{1,3}

## DB of "Basket Data"

TID	items
100	1 3 4
200	2 3 5
300	1 2 3 5
400	2 5

## association rules

{1} => {3}

{2,3} => {5}

{2,5} => {3}

⋮



## association rule metrics:

$$\text{confidence} \equiv \frac{\left| \text{transactions containing } IS_a \cup IS_c \right|}{\left| \text{transactions containing } IS_a \right|}$$

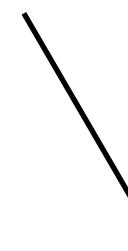
$$\text{support} \equiv \frac{\left| \text{transactions containing } IS_a \cup IS_c \right|}{\left| \text{all transactions} \right|}$$

Typically, association rules are considered interesting if they satisfy both a **minimum support threshold** and a **minimum confidence threshold**

# Apriori Method

“When a customer who buys sugar, in **70%** of the cases, he or she will also buy milk!”  
We find this happens in **13.5%** of all purchases”

Confidence



support

Fast algorithms for mining association rules

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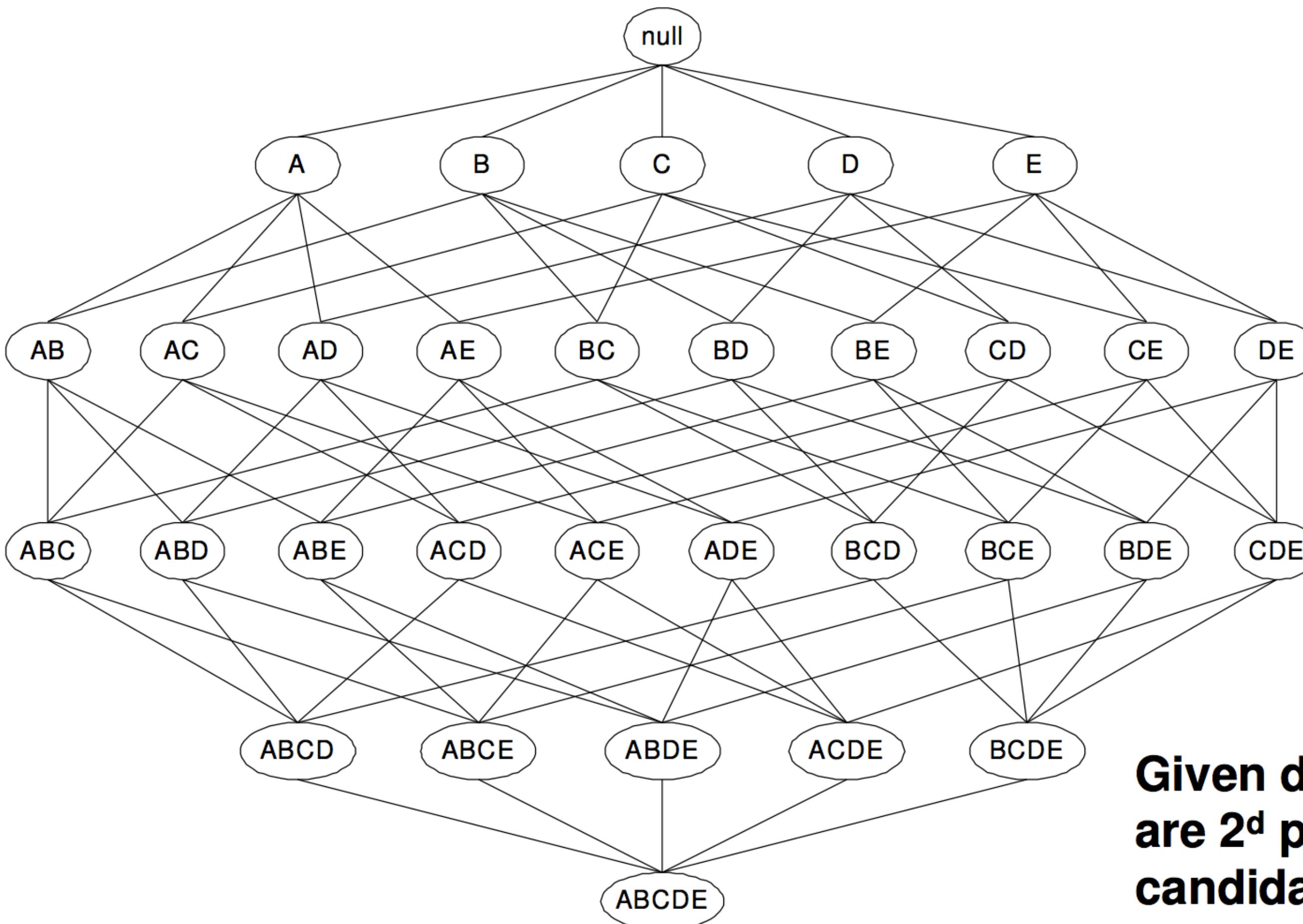
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**Sugar -> Milk**

*Support = 13.5% and confidence = 70%*

# Association Rules



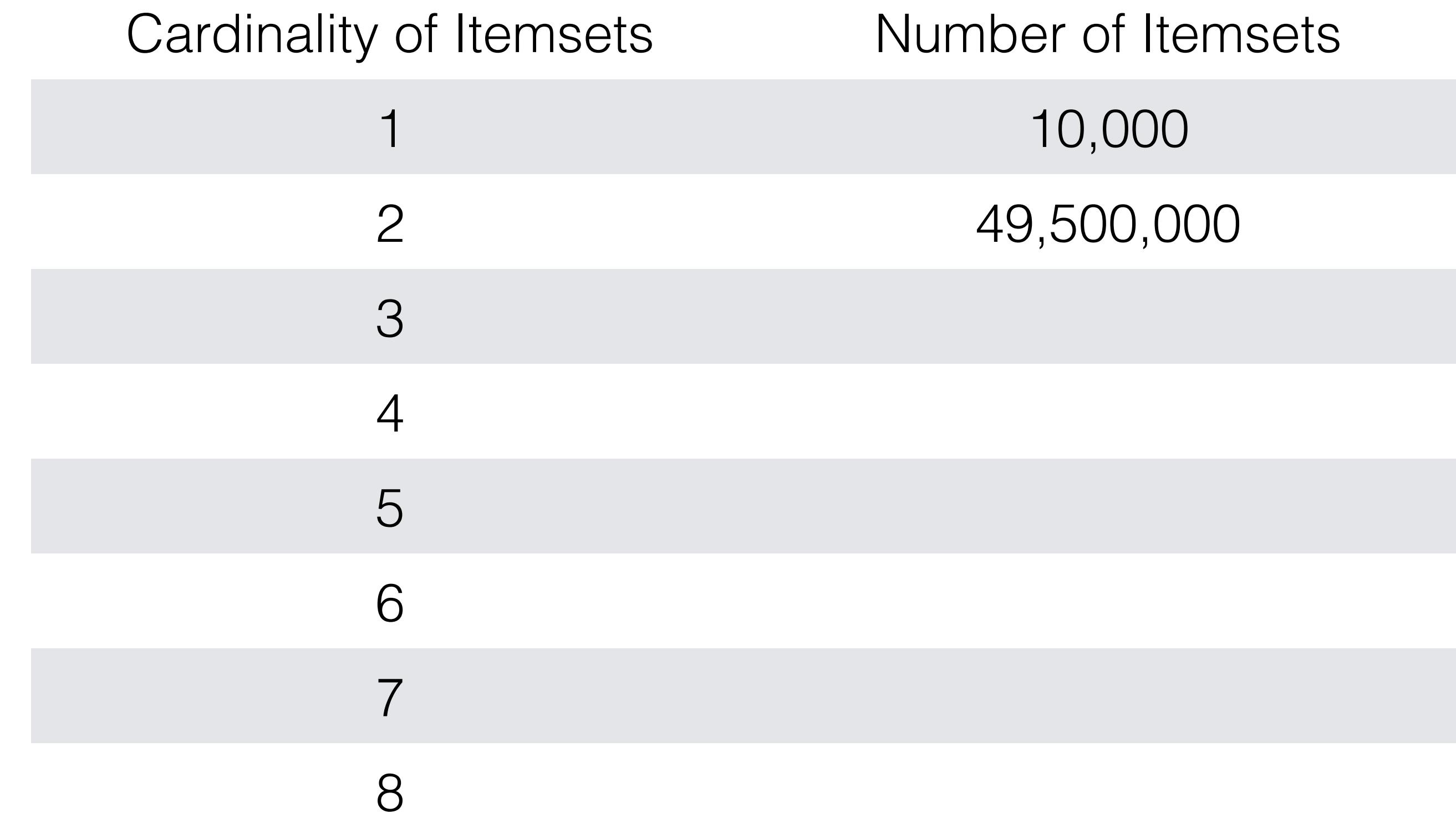
**Given  $d$  items, there  
are  $2^d$  possible  
candidate itemsets**

# Some interesting numbers

Cardinality of Itemsets	Number of Itemsets
1	100
2	4,950
3	161,700
4	3,921,225
5	75,287,529
6	1,192,052,400
7	16,007,560,800
8	186,087,894,300

If the supermarket has 100 products

# Some interesting numbers



If a supermarket has at least 10,000 different items, there are almost 50,000,000 possible 2-itemsets, imagine how many with 3-itemsets and 4-itemsets

# Frequent Item sets

- Ideally, we want to create all possible combinations of items
- **Problem:** computation grows exponentially as #items increases... Brute force is not feasible
- **Solution:** Consider only “frequent items sets”
  - Criterion for frequent: **support**

# Apriori Method

**Apriori principle:** Any subset of a frequent itemset must be frequent

**Step 1:** Find the frequent itemsset: the set of items that have minimum support.

- A subset of a frequent itemset must also be a frequent itemset
  - i.e. if  $\{1,2\}$  is a frequent itemset, both  $\{1\}$  and  $\{2\}$  should be a frequent itemset
- Iteratively find frequent itemsets with cardinality from 1 to k (k-itemset)

**Step 2:** Use the frequent itemsets to generate association rules

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# Association Rules

- **Step I:** Find all itemsets with *minimum support (minsup)*

<u>TID</u>	<u>items</u>	<u>support</u>	<u>itemsets</u>
100	1 3 4	0.25	{4}, {1,2}, {1,4}, {1,5}, {3,4}, {1,3,4}, {1,2,3}, {1,2,5}, {1,3,5}, {1,2,3,5}
200	2 3 5		
300	1 2 3 5	0.5	{1}, {1,3}, {2,3}, {3,5}, {2,3,5}
400	2 5	0.75	{2}, {3}, {5}, {2,5}

- **Step II:** Generate rules from *minsup'ed itemsets*

<u>support</u>	<u>confidence</u>	<u>rules</u>
0.5	66%	{3}>>{1}, {3}>>{2}, {2}>>{3}, {3}>>{5}, {5}>>{3}, {5}>>{2,3}, {3}>>{2,5}, {2}>>{3,5}, {5,2}>>{3}, {5,3}>>{2}
0.5	100%	{1}>>{3}, {5,3}>>{2}, {2,3}>>{5}
0.75	100%	{5}>>{2}, {2}>>{5}

Fast algorithms for mining association rules

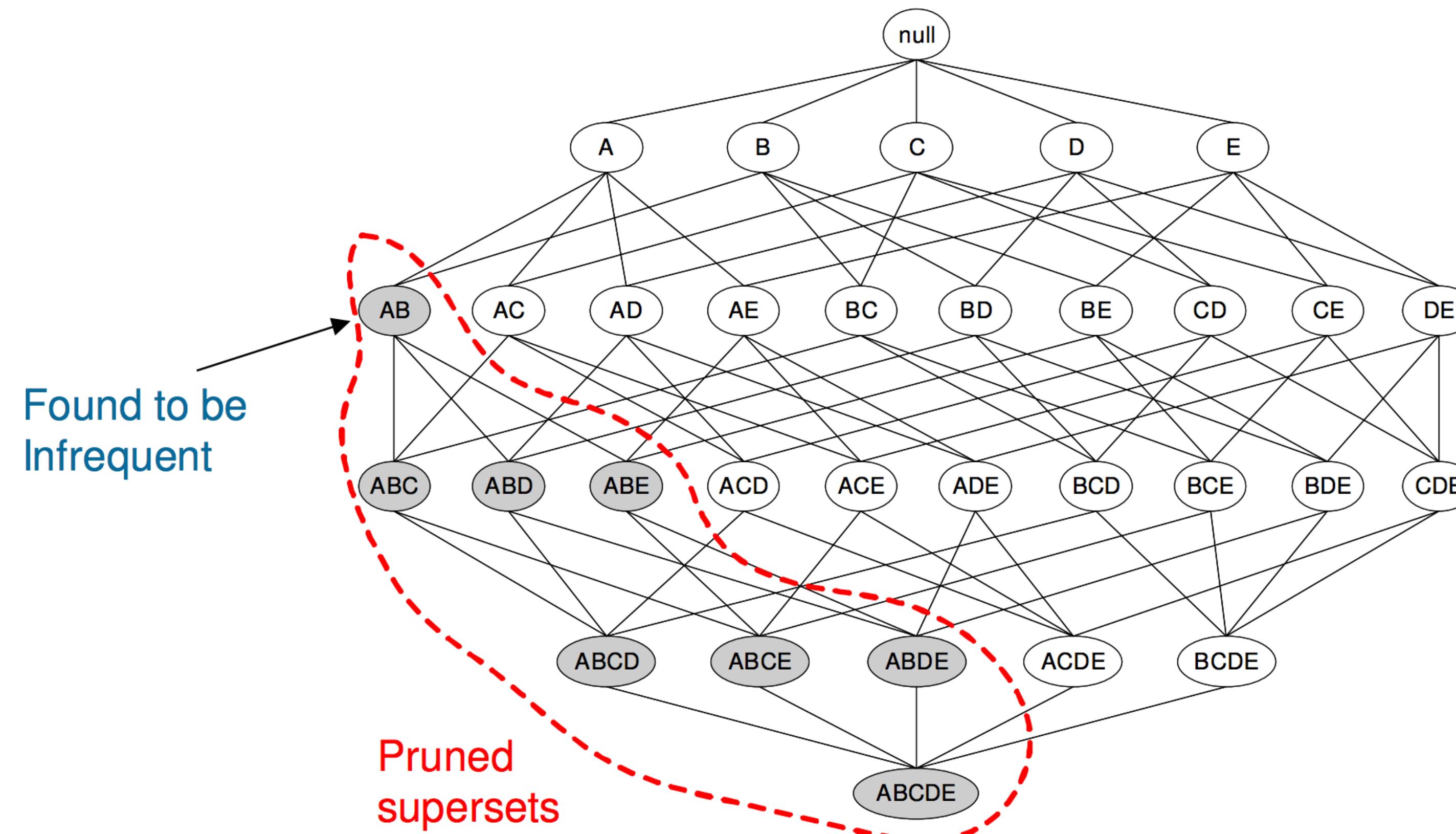
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# Apriori Method



# Apriori Method

Apriori( $T, \epsilon$ )

$L_1 \leftarrow \{\text{large 1-itemsets}\}$

$k \leftarrow 2$

**while**  $L_{k-1} \neq \emptyset$

$C_k \leftarrow \{a \cup \{b\} \mid a \in L_{k-1} \wedge b \notin a\} - \{c \mid \{s \mid s \subseteq c \wedge |s| = k-1\} \not\subseteq L_{k-1}\}$

**for** transactions  $t \in T$

$C_t \leftarrow \{c \mid c \in C_k \wedge c \subseteq t\}$

**for** candidates  $c \in C_t$

$count[c] \leftarrow count[c] + 1$

$L_k \leftarrow \{c \mid c \in C_k \wedge count[c] \geq \epsilon\}$

$k \leftarrow k + 1$

**return**  $\bigcup_k L_k$

Fast algorithms for mining association rules

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# **Caution:** The role of Chance

- Random data can generate apparently interesting association rules
- The more rules you produce, the greater this danger
- Rules based on large number of records are less subject to this danger

# Interesting Measures

- Are all of these discovered association rules interesting enough to present to the user?
- How can we **measure the interestingness** of a rule?
- **Subjective** measures:
  - A rule (pattern) is interesting if:
    - it is **unexpected** (surprising to the user) and/or **actionable** (the user can do something with it)

# Criticism to Support and Confidence

- Example. Among 5000 students:
  - **3000** plays basketball — **3750** eat cereal
  - **2000** both play basketball and eat cereal

	basketball	not basketball	sum(row)
cereal	2000	1750	<b>3750</b>
not cereal	1000	250	1250
sum(col)	<b>3000</b>	2000	<b>5000</b>

# Criticism to Support and Confidence

the question is:

**Should I recommend cereals to those who play basketball?**

	basketball	not basketball	sum(row)
cereal	2000	1750	3750
not cereal	1000	250	1250
sum(col)	3000	2000	5000

# Criticism to Support and Confidence

the question is:

**Should I recommend cereals to those who play basketball?**

play basketball → eat cereal?

or

play basketball → not eat cereal?

	basketball	not basketball	sum(row)
cereal	2000	1750	3750
not cereal	1000	250	1250
sum(col)	3000	2000	5000

# Criticism to Support and Confidence

- Example. Among 5000 students:
  - 3000 plays basketball — 3750 eat cereal
  - 2000 both play basketball and eat cereal

	basketball	not basketball	sum(row)	
cereal	2000	1750	3750	75%
not cereal	1000	250	1250	25%
sum(col)	3000	2000	5000	
	60%	40%		

**Should I recommend cereals to those who play basketball?**

play basketball —> eat cereal

[support: 40% - Conf: 66.66%]

play basketball —> not eat cereal

[support: 20% - Conf: 33.33%]

# Objective measure of rule of interest

- Support
- Confidence or strength
- Lift or interest or Correlation
- Conviction
- Leverage or Piatetsky-Shapiro
- Coverage

# Lift of a rule

$$\text{Lift}(\text{X} \rightarrow \text{Y}) = \frac{\text{sup}(\text{X and Y})}{\text{sup}(\text{X}) \text{sup}(\text{Y})}$$

**X** and **Y** negatively correlated, if the value is less than 1;  
otherwise **X** and **Y** positively correlated

	basketball	not basketball	sum(row)	
cereal	2000	1750	3750	75%
not cereal	1000	250	1250	25%
sum(col)	3000	2000	<b>5000</b>	
	60%	40%		

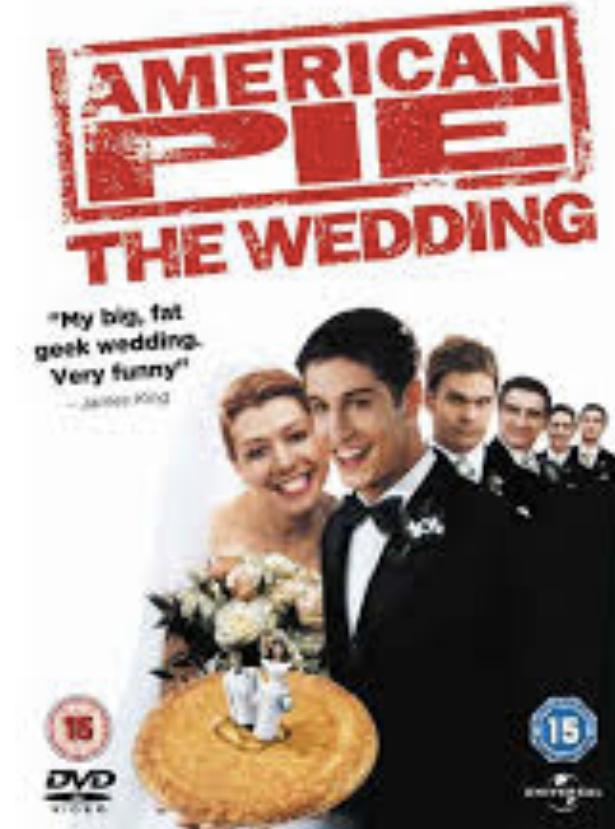
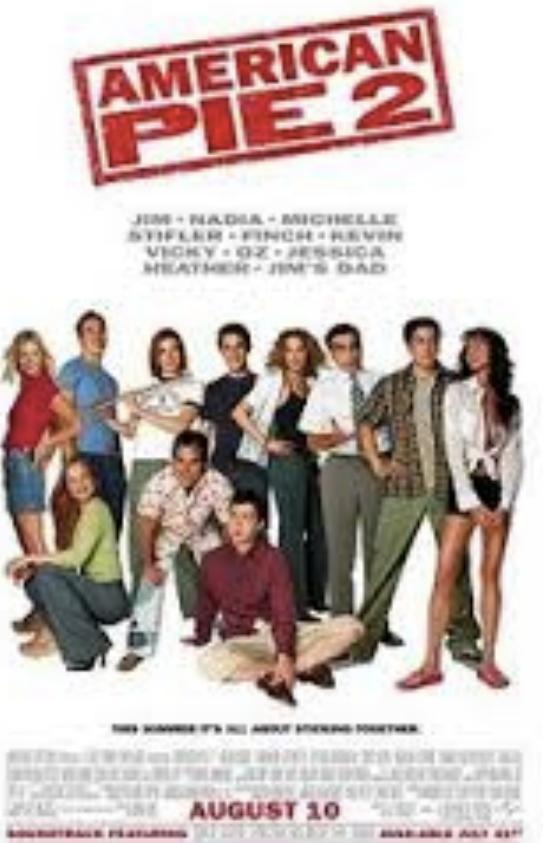
play basketball → eat cereal [40% - 66.66%] → **Lift = 0.89**  
play basketball → not eat cereal [20% - 33.33%] → **Lift = 1.33**

# Lift of a Rule

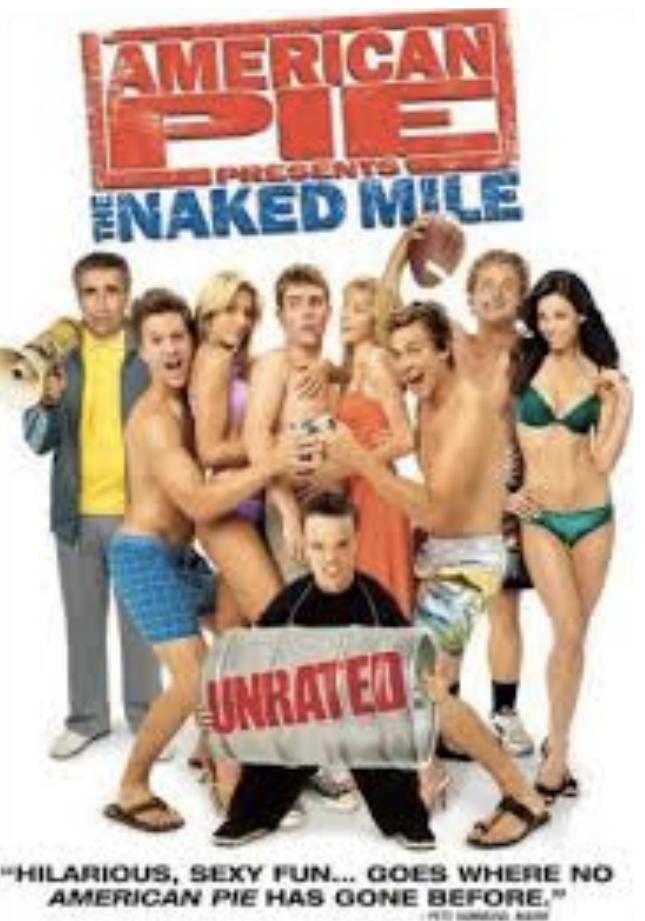
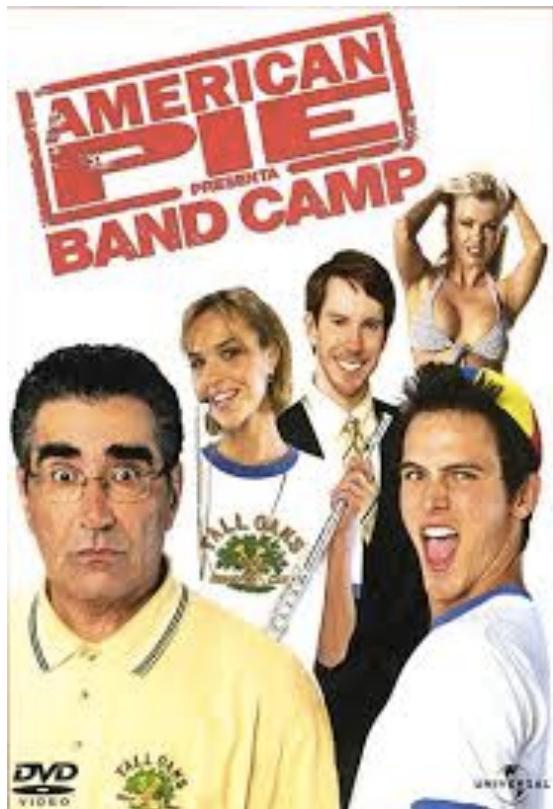
$$\text{Lift}(\mathbf{X} \rightarrow \mathbf{Y}) = \frac{\text{sup}(\mathbf{X} \text{ and } \mathbf{Y})}{\text{sup}(\mathbf{X}) \text{ sup}(\mathbf{Y})}$$

Problems with **Lift**:

- a) Rules that hold 100% of the time may not have the highest possible lift.
- b) It is symmetric



# Association rules for movie recommendations?



# Movie Recommendations based on Association Rules?

**Hands on time!**



# Apriori on MovieLens?

market basket will have positive and negative samples.

>4 Like

<=4 Not like