Master on Foundations of Data Science

Recommender Systems

Graph Based Models

Santi Seguí | 2019-2020

Modeling taste with Cassandra

Graph models for Neighborhood-Based Methods

- Sparsity of observed ratings causes a major problem in the computation of similarity in neighborhood-based methods.

- Graph-models can be used in order to **define similarity** in the neighborhood-based methods

  - using either structural transitivity or ranking techniques

- Provide a **structural representation** of the relationships **among** various **users** and/or **items**

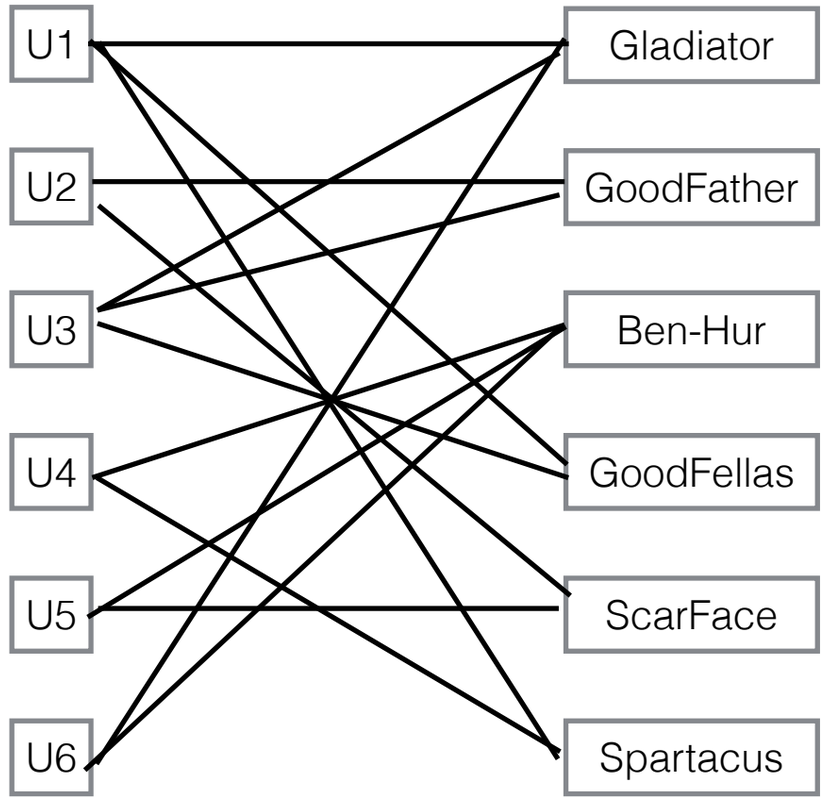
User-Item Graphs

- More effective than Pearson Correlation when **dealing** with **very sparse datasets**
- User-Item graph defined as an undirected and bipartite graph:

$$G = (N_u \cup N_i, A)$$

User-Item Graphs

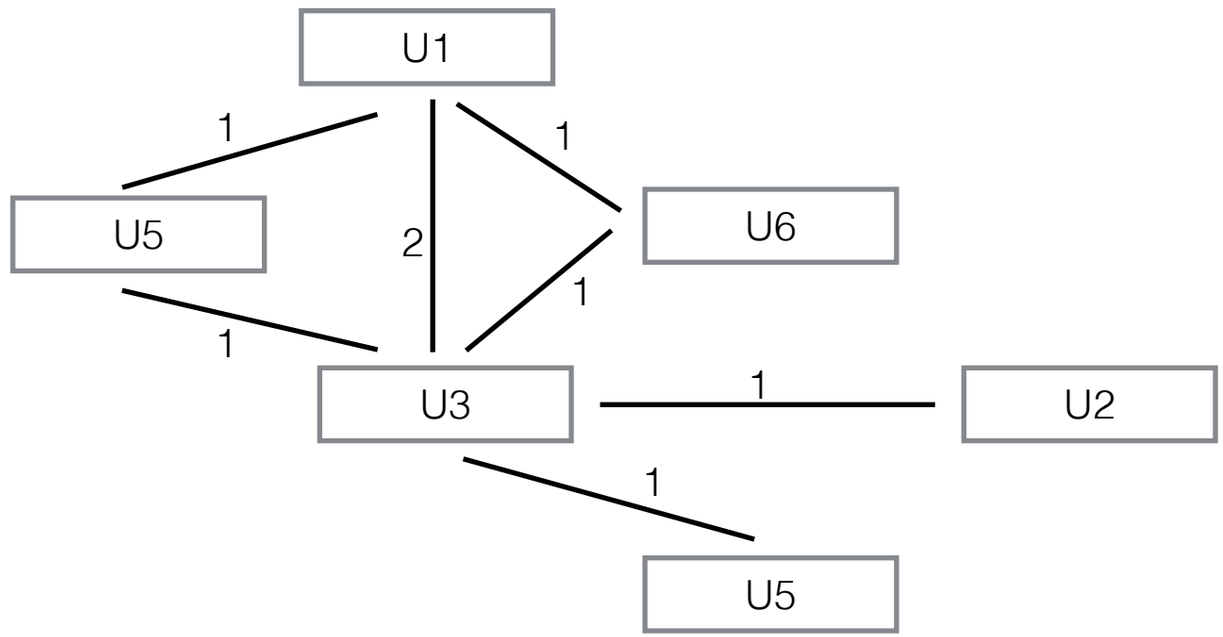
Items	Gladiator	GoodFather	Ben-Hur	GoodFellas	ScarFace	Spartacus
U1	1			5		2
U2		5			4	
U3	5	3		1		
U4			3			4
U5				3	5	
U6	5		4			



User-User Graphs

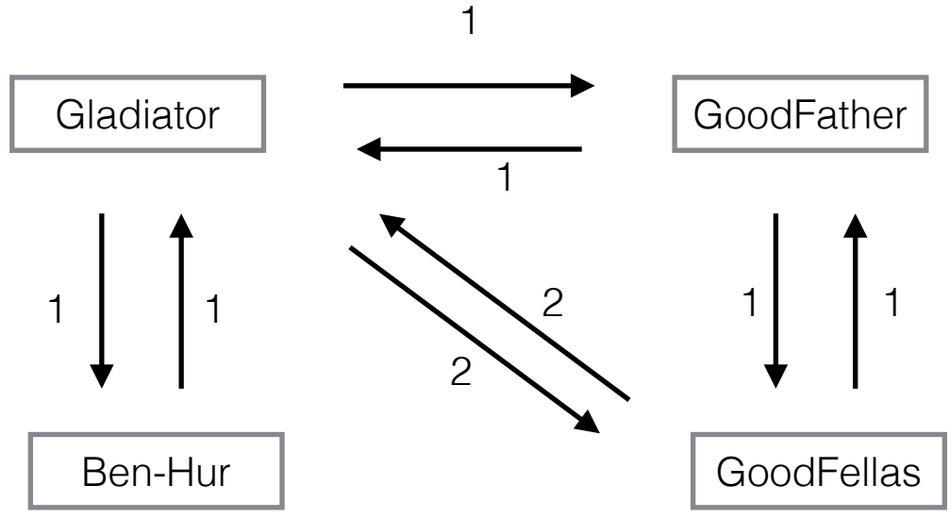
- User-user Graph based on 2-hop connectivity between users

	Gladiator	GoodFather	Ben-Hur	GoodFellas
U1	1			5
U2		5		
U3	5	3		1
U4			3	
U5				3
U6	5		4	

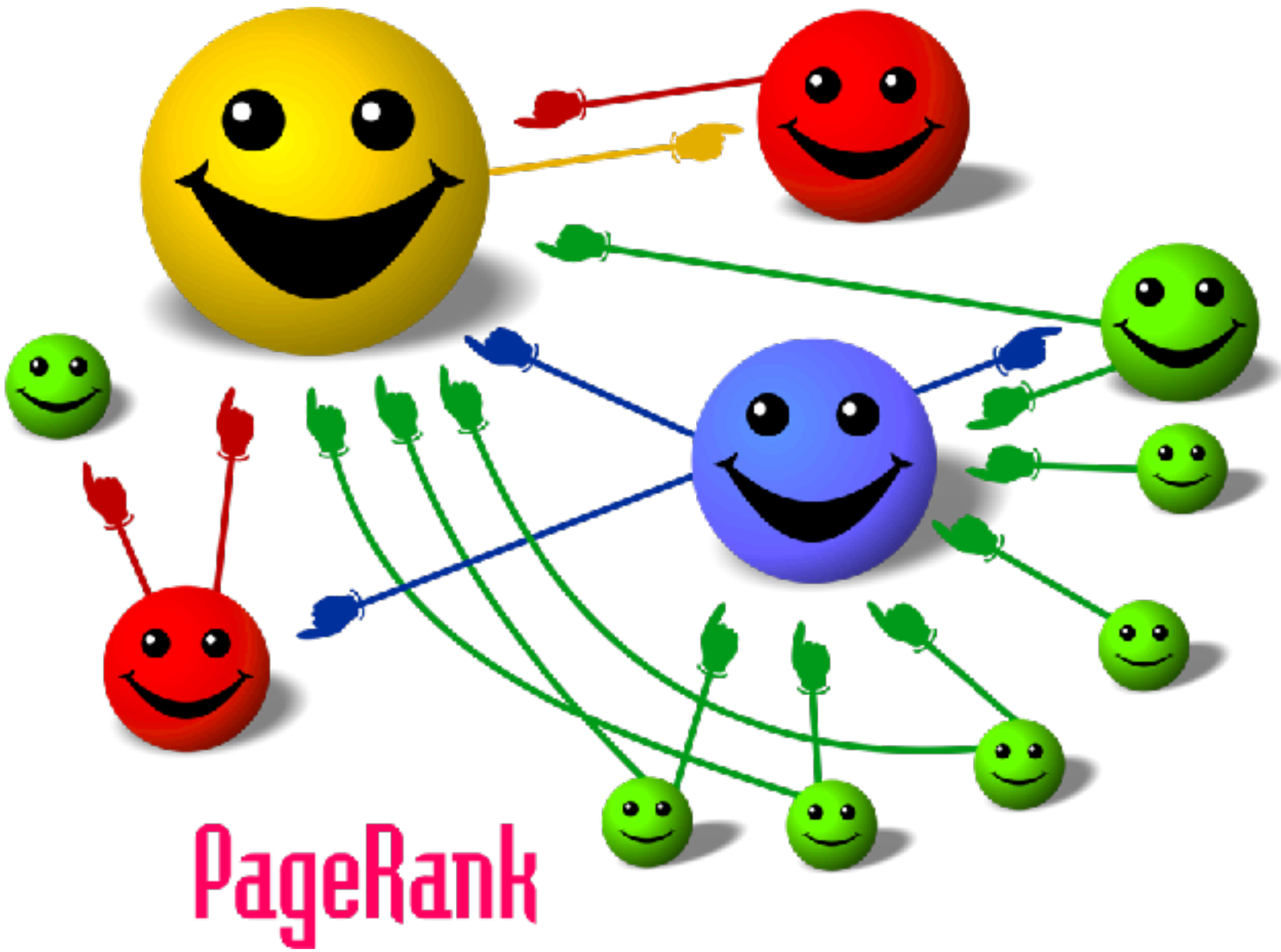


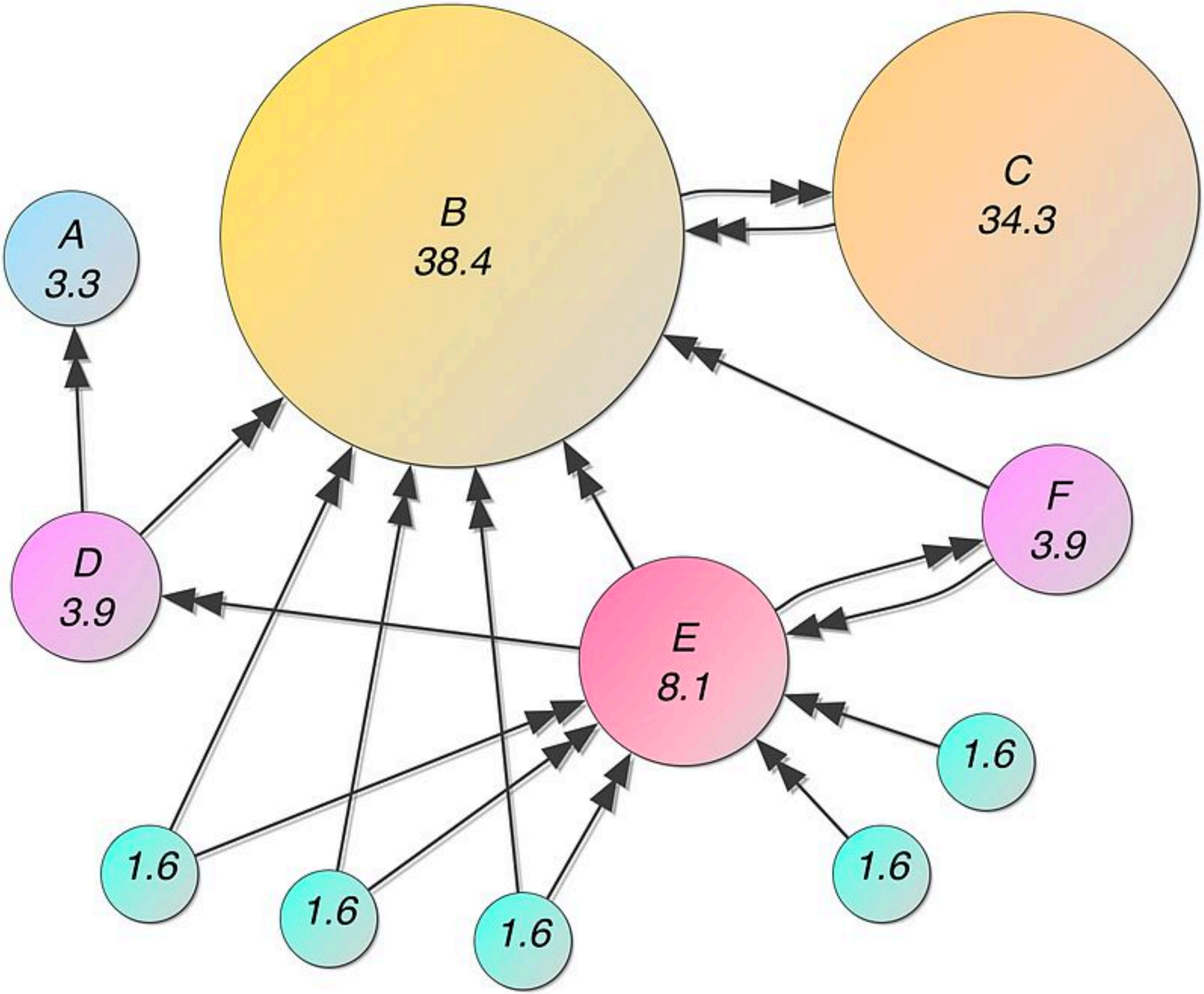
Item-Item Graphs

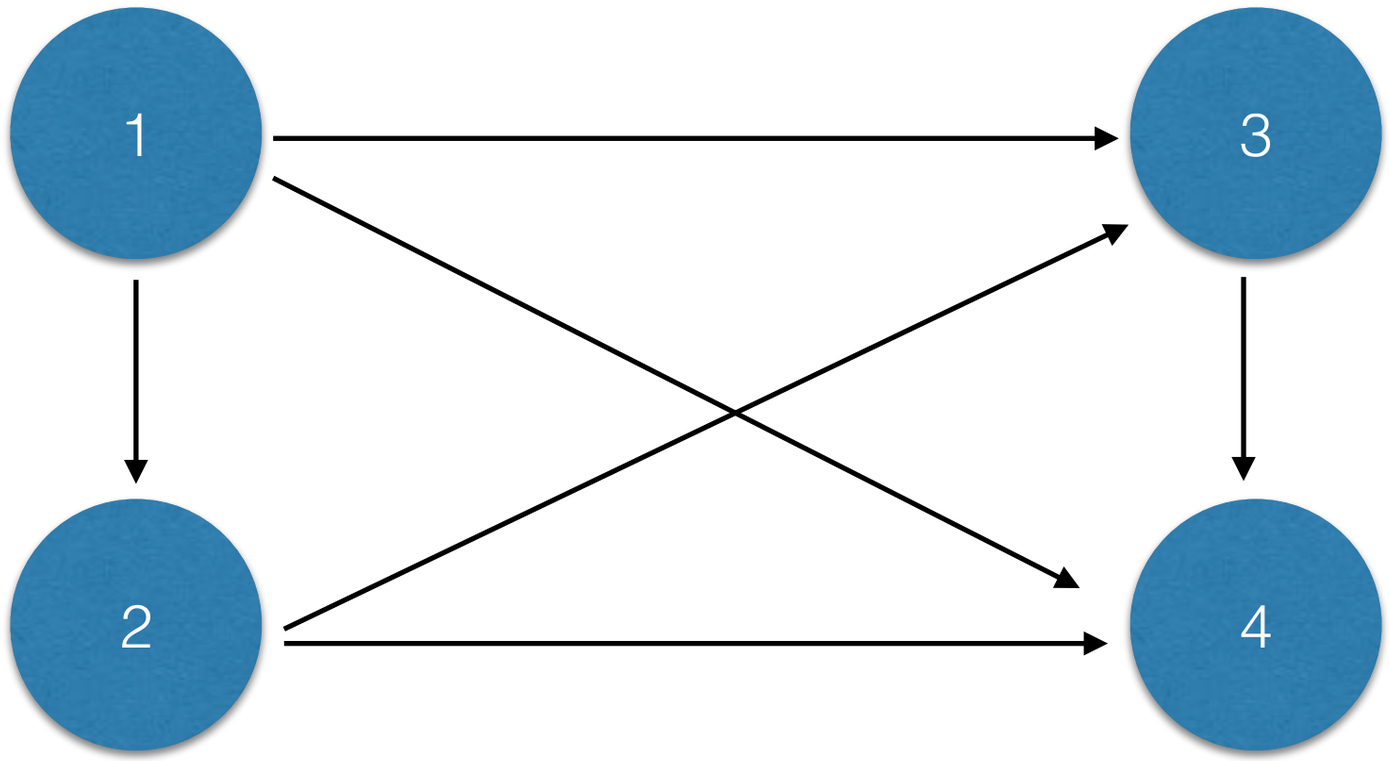
	Items			
	Gladiator	GoodFather	Ben-Hur	GoodFellas
U1	1			5
U2		5		
U3	5	3		1
U4			3	
U5				3
U6	5		4	

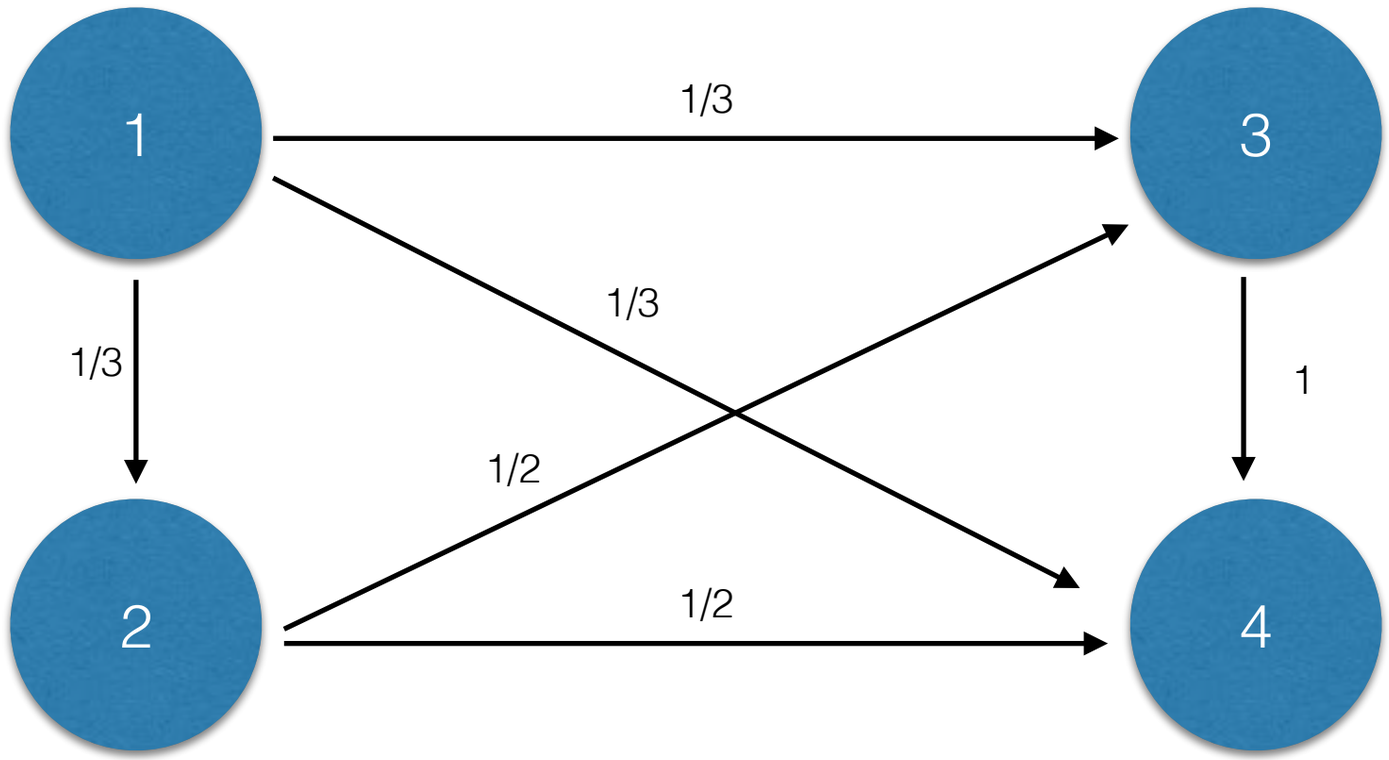


PageRank




A
3.3
B
38.4
C
34.3
D
3.9
E
8.1
F
3.9
1.6
1.6
1.6
1.6
1.6


1
3
2
4



The idea is:
If you navigate as a random walk using the weight as probabilities move from one node to the other, how many times each node will be visited?

PageRank

- The PageRank algorithm was first proposed in the context of ***Web Search***
- The PageRank algorithm generalizes the notion of citation-based ranking in a recursive way

$$x' = (1-\alpha)Ax + \alpha\frac{1}{n}S \longrightarrow$$ Know as **restart** Matrix

where:
A is the adjacency matrix,
S is a matrix of ones and
α is a damping factor, generally fixed to 0.15

Solution with Power Iteration Method

1			5		2
	5			4	
5	3		1		
		3			4
			3	5	
5		4			

x

x1
x2
x3
x4
x5
x6

=

x1’
x2’
x3’
x4’
x5’
x6’

1st (and important) Step:
First Normalize your Adjancecy Matrix

1/11			5/9		2/6
	5/8			4/9	
5/11	3/8		1/9		
		3/7			4/6
			3/9	5/9	
5/11		4/7			

X

x1
x2
x3
x4
x5
x6

=

x1’
x2’
x3’
x4’
x5’
x6’

1/11			5/9		2/6
	5/8			4/9	
5/11	3/8		1/9		
		3/7			4/6
			3/9	5/9	
5/11		4/7			

X

1
1
1
1
1
1

=

0,98
1,07
0,94
1,10
0,89
1,03

2nd Step: Initialize your vector and compute

2nd iteration
update x values

1/11			5/9		2/6
	5/8			4/9	
5/11	3/8		1/9		
		3/7			4/6
			3/9	5/9	
5/11		4/7			

X

0,98
1,07
0,94
1,1
0,98
1,03

=

1,04
1,10
0,97
1,09
0,91
0,98

3rd iteration
update x values

1/11			5/9		2/6
	5/8			4/9	
5/11	3/8		1/9		
		3/7			4/6
			3/9	5/9	
5/11		4/7			

X

1,04
1,1
0,97
1,09
0,91
0,98

=

1,03
1,09
1,01
1,07
0,87
1,03

4th iteration
update x values

1/11			5/9		2/6
	5/8			4/9	
5/11	3/8		1/9		
		3/7			4/6
			3/9	5/9	
5/11		4/7			

X

1,03
1,09
1,01
1,07
0,87
1,03

=

1,03
1,07
1,00
1,12
0,84
1,05

and iterate until convergence

More about PageRank and Power Iteration:

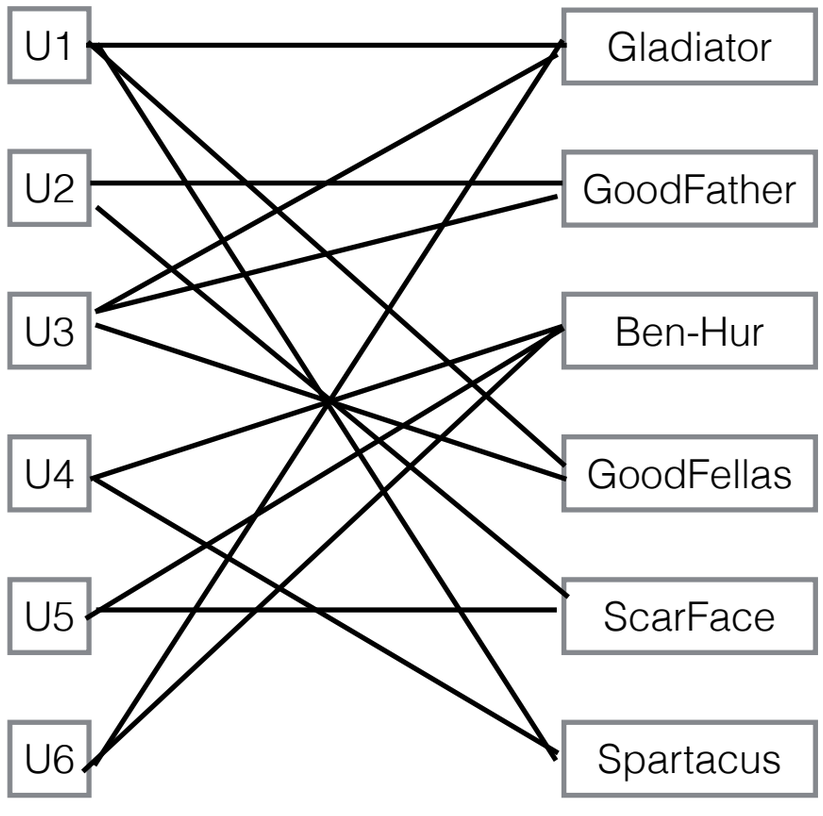
https://www.youtube.com/watch?v=VpiyOxiVmCg

Page Rank: How graph must be constructed?

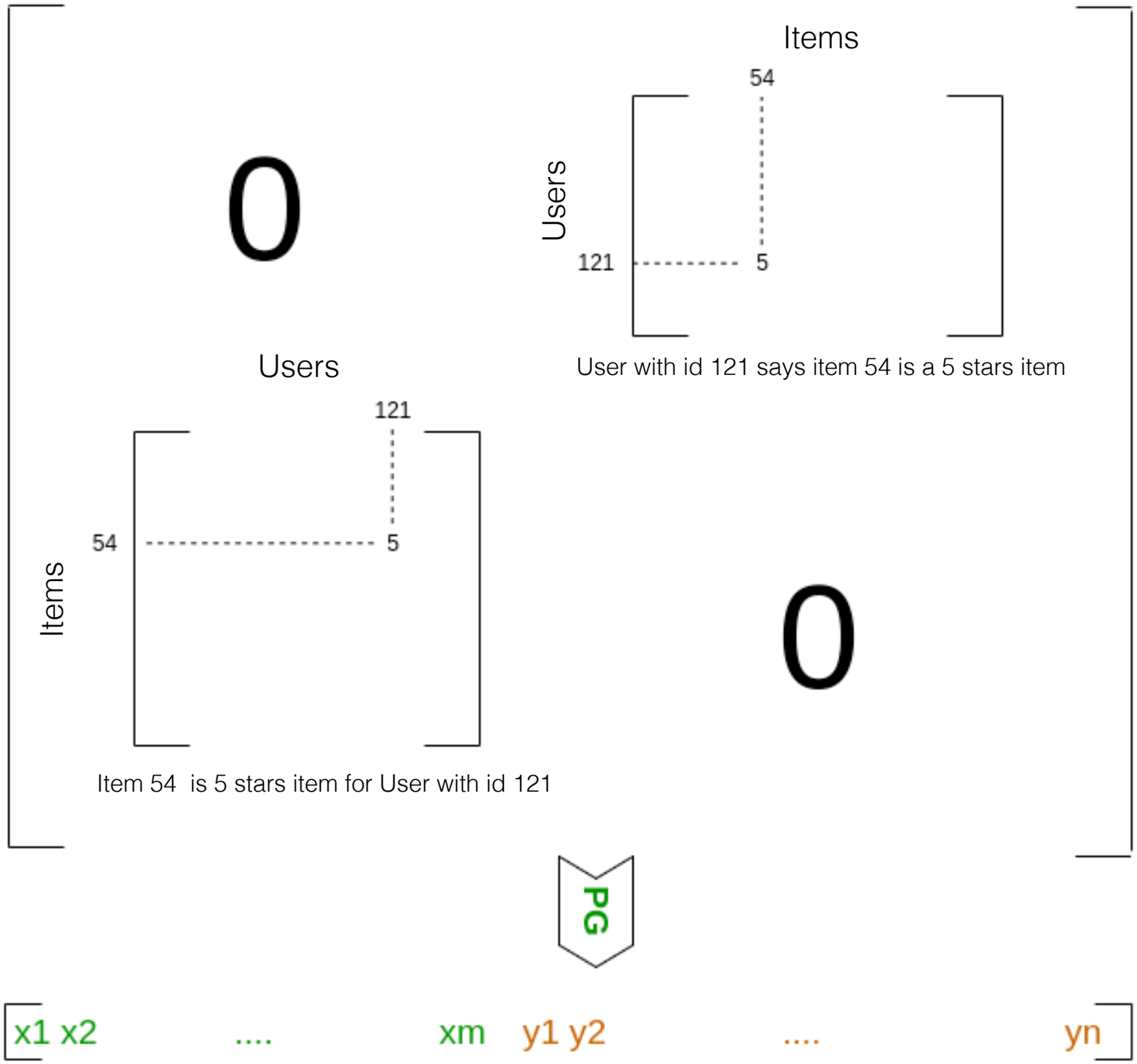
Items

	Gladiator	GoodFather	Ben-Hur	GoodFellas	ScarFace	Spartacus
U1	1			5		2
U2		5			4	
U3	5	3		1		
U4			3			4
U5				3	5	
U6	5		4			

?	?	?	?	?	?	?



Page Rank: Extended graph



Page Rank: How graph must be constructed?

	U1	U2	U3	U5	U5	U6
U1	1			5		2
U2		5			4	
U3	5	3		1		
U4			3			4
U5				3	5	
U6	5		4			

User/User graph

User Weight?

PageRank is not directly a recommendation approach

it is Not personalized

Defining Neighborhoods

- The neighborhood of a user is defined by the **set of users that are encountered frequently in a random walk starting at that user**.

- How can we measure similarity between users/items using a graph?

  - Katz measure

  - **Personalized PageRank**

  - SimRank method

Personalized PageRank

- *PageRank* is an excellent mechanism to find popular nodes in terms of the linkage structure, however it does little for finding items that are well-matched to interest of specific users.

- The notion of ***personalized PageRank*** is designed to find **popular** nodes, which **are also similar to specific node** in the network

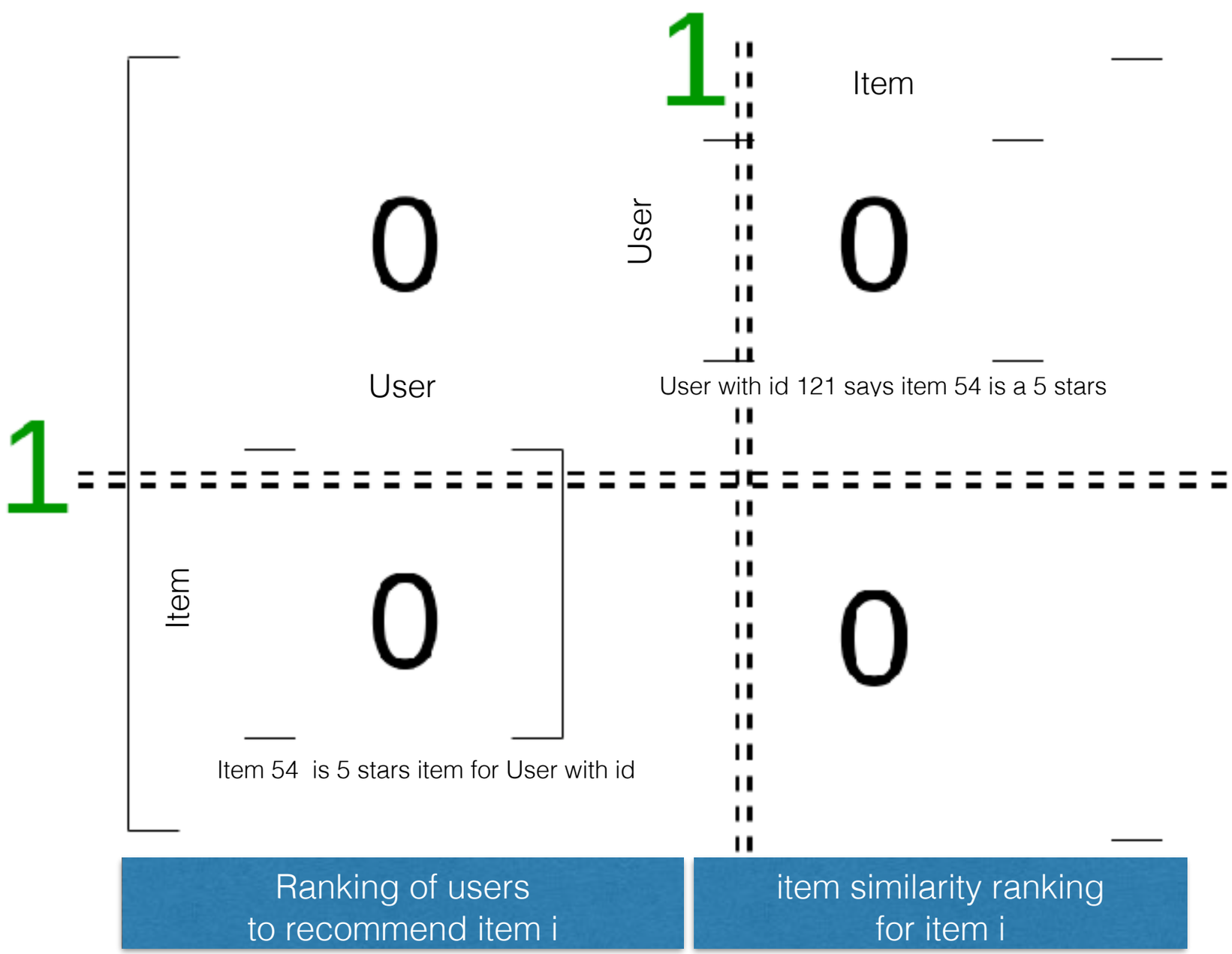
- A node receives an amount of rank from every node which points to it and in turn transfer an amount of its rank to the node it refers to.

Personalized PageRank

- Two main methods:
  - **Random walk** with restart at a particular item in order to determine the relevant neighborhoods
  - **ItemRank**. For each user *i*, a different PageRank restart vector is used.

Personalized PageRank

Random Walk



The restart matrix only contain non-zero values to **the column and row** correspoding to **item i**

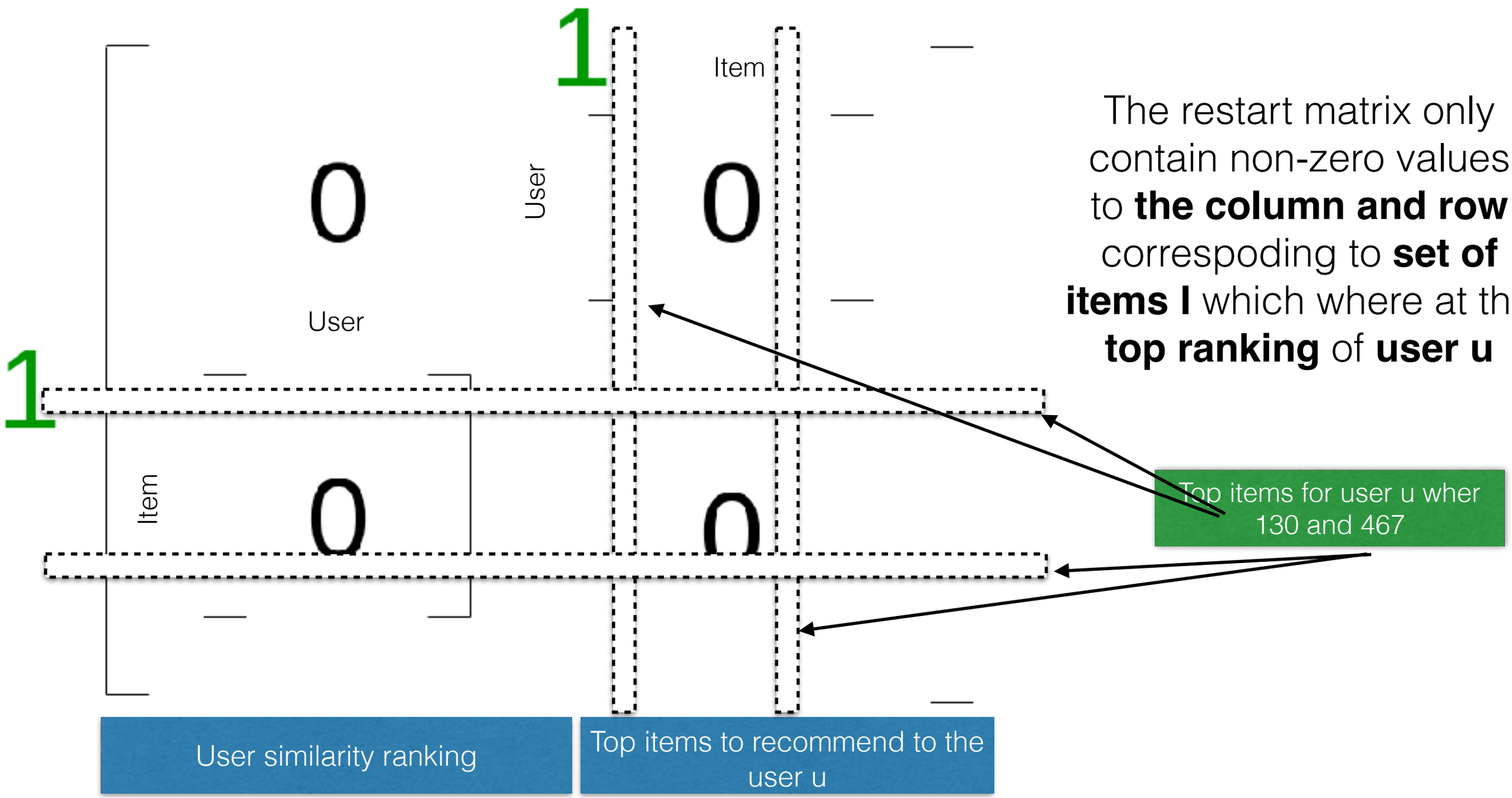
Personalized PageRank

- **ItemRank**. For each user *i*, a different PageRank restart vector is used.
- PageRank equations are specific to user *i* and one need to solve this system *m* times in order to determine the preferences of all users.

$$E(j) = \begin{cases} 1/n & \text{if } j \text{ in } I_u \\ 0 & \text{otherwise} \end{cases}$$

Personalized PageRank

Item Rank



The restart matrix only contain non-zero values to **the column and row** correspoding to **set of items I** which where at the **top ranking** of **user u**

Task #3

- **Problem**: JOKES recommendations

- **Methods to implement:**
    - **Graph-Based recommender system**
    - Any other method that you think will be the best for the task
- **Evaluation**:
    - OFFLINE: MSE
- **What to deliver:**
    - Jupyter notebook
- **Deadline**:
    - May 30th

https://www.kaggle.com/c/jesterdsub2020

InClass Prediction Competition

Jester Recommendations System

Jokes recommendations using jester dataset

2 months to go

Overview | Data | Kernels | Discussion | Leaderboard | Rules

Overview

Description

Evaluation

- Jester dataset includes user ratings ranging from -10 to +10 for 100 jokes.
- NOTE: original dataset has been modified with noise and data perturbation
- RMSE will be used for evaluation.
- Once you submit a result, it will list you in the leaderboard based on the best score of your submissions.

TEAMS are allowed. From 1-3 persons

https://www.kaggle.com/c/jesterdsub2020

Jester 5.0

Jokes for *your* sense of humor

First rate two jokes.

Q: If a person who speaks three languages is called "trilingual," and a person who speaks two languages is called "bilingual," what do you call a person who only speaks one language?

A: American!

Less Funny More Funny

Next