Similar Users or Similar Items? Comparing Similarity-based Approaches for Recommender Systems in Online Judges
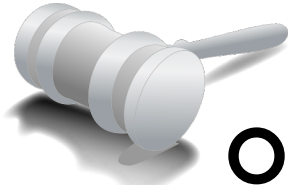
Marta Caro Martínez, Guillermo Jiménez Díaz
{martcaro, gjimenez}@ucm.es

UNIVERSIDAD COMPLUTENSE MADRID

## Recommender Systems for Online Judges?

Online judges are platforms that
o store a huge amount of programming problems
o compile and execute submitted solutions against test cases
o provide verdicts for solutions to these problems
o for programming contests and to practice programming skills

Why do they need recommender systems Users need help to choose which problem should solve next

~~Ratings~~   ~~Descriptions~~
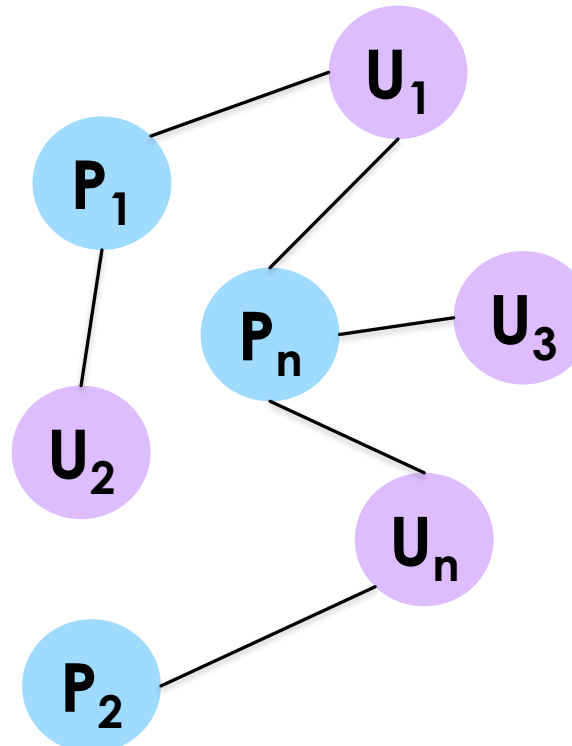
Online judge interactions represented by a **bipartite graph**

o NODES: users or problems
o LINKS: user attempted to solve a problem
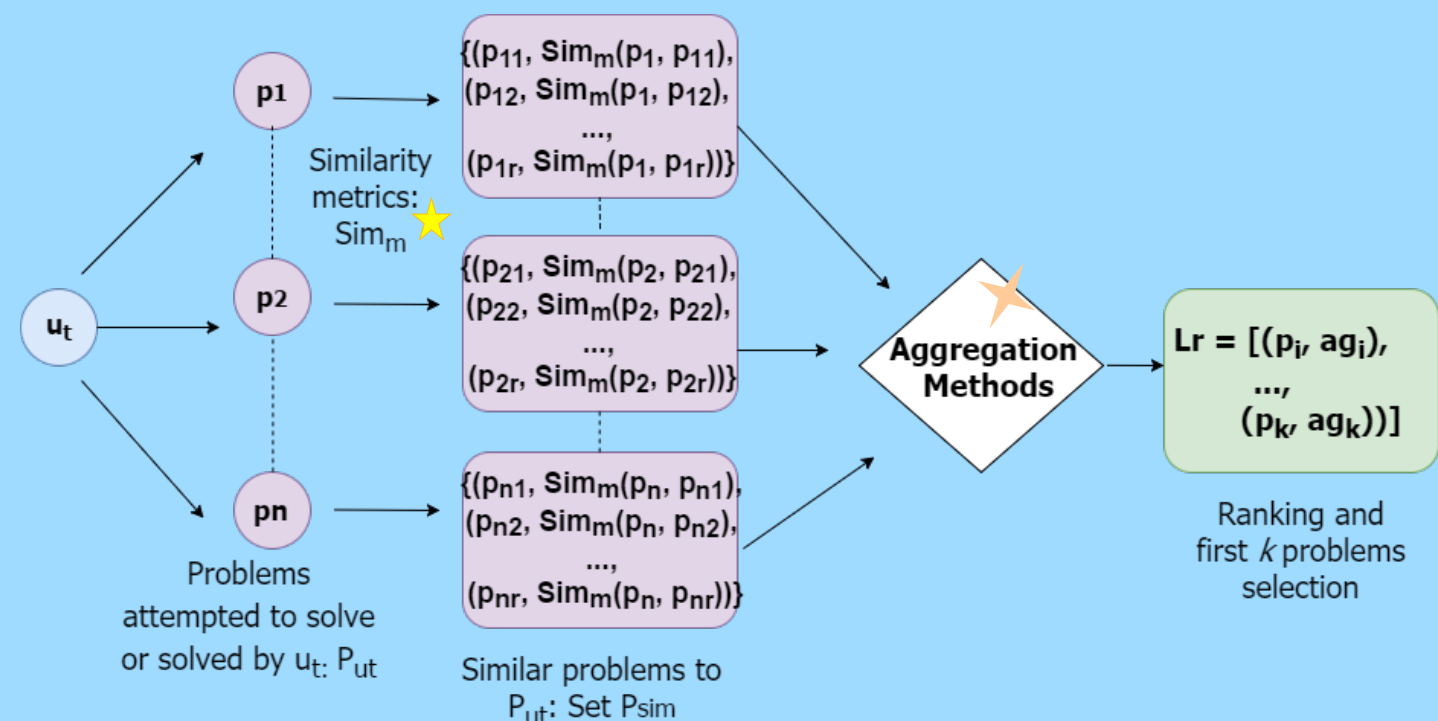user solved a problem

Network projection transforms a bipartite graph into a non-bipartite one

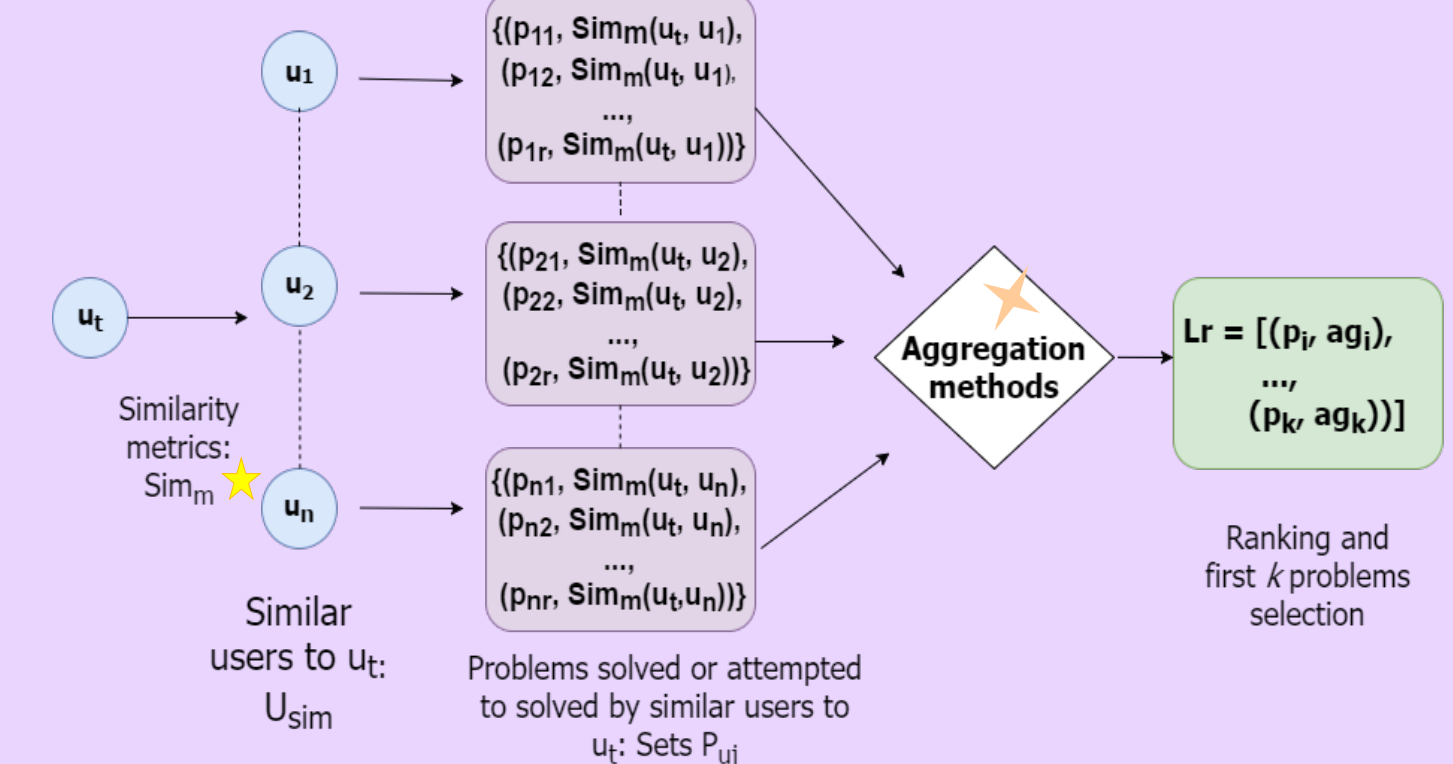o Problem - Problem
o User - User

Network projection

Problem-based approach

o NODES: Problems
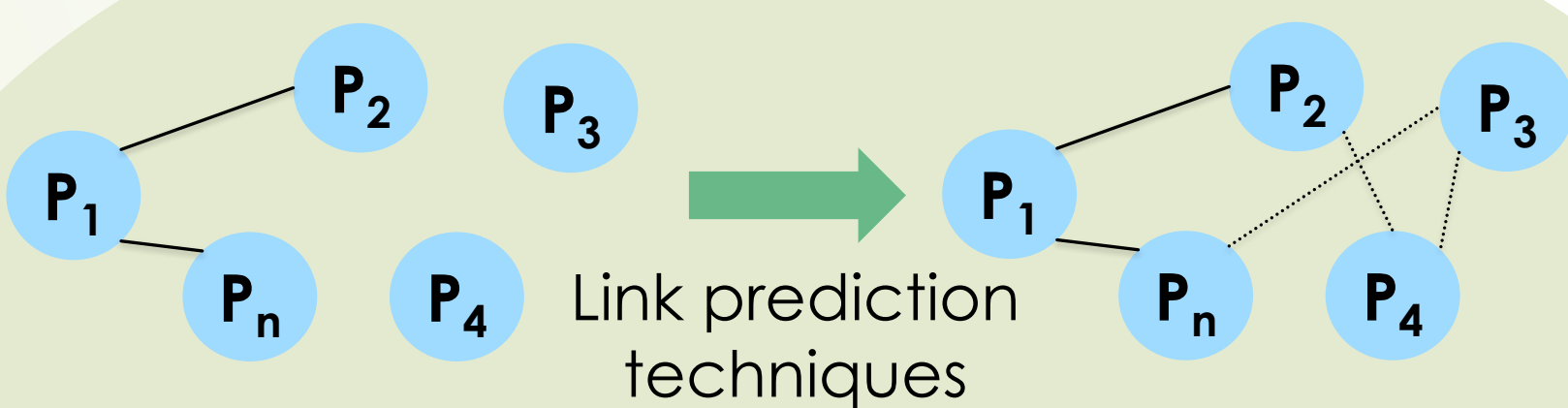o LINKS: Common users who solved both problems

Similarity metrics: Sim_m

Problems attempted to solve or solved by u_t: P_{ut}

Similar problems to P_{ut}: Set P_{sim}

$\{(p_{11}, Sim_m(p_1, p_{11}), (p_{12}, Sim_m(p_1, p_{12}), ..., (p_{1r}, Sim_m(p_1, p_{1r}))\}$

$\{(p_{21}, Sim_m(p_2, p_{21}), (p_{22}, Sim_m(p_2, p_{22}), ..., (p_{2r}, Sim_m(p_2, p_{2r}))\}$

$\{(p_{n1}, Sim_m(p_n, p_{n1}), (p_{n2}, Sim_m(p_n, p_{n2}), (p_{nr}, Sim_m(p_n, p_{nr}))\}$

Aggregation Methods

$L_r = [(p_i, ag_i), ..., (p_k, ag_k)]$

Ranking and first k problems selection

User-based approach

o NODES: Users
o LINKS: Common problems solved by both users

Similarity metrics: Sim_m

Similar users to u_t: U_{sim}

$\{(p_{11}, Sim_m(u_t, u_1), (p_{12}, Sim_m(u_t, u_1), ..., (p_{1r}, Sim_m(u_t, u_1))\}$

$\{(p_{21}, Sim_m(u_t, u_2), (p_{22}, Sim_m(u_t, u_2), ..., (p_{2r}, Sim_m(u_t, u_2))\}$

$\{(p_{n1}, Sim_m(u_t, u_n), (p_{n2}, Sim_m(u_t, u_n), (p_{nr}, Sim_m(u_t, u_n))\}$

Problems solved or attempted to solved by similar users to u_t: Sets P_{ul}

Aggregation methods

$L_r = [(p_i, ag_i), ..., (p_k, ag_k)]$

Ranking and first k problems selection

Link prediction: similarity metrics

Link prediction techniques

Sim_m matrix >> similarity between pairs of nodes based on link prediction tecniques

$Sim_m(i,j)$ >> similarity score between the nodes p_i and p_j using the similarity metric m

Aggregation methods

Max. similarity value   vs.   Voting systems

Simple voting   Weighted voting   Positional voting

Example

User	pos_{u_j}	Problems/Similarity	Similarity value
u_3	1	$\{(p_1, 5), (p_2, 5), (p_5, 5)\}$	$Sim_m(u_t, u_3) = 5$
u_1	2	$\{(p_1, 4), (p_2, 4), (p_4, 4)\}$	$Sim_m(u_t, u_1) = 4$
u_2	3	$\{(p_2, 2), (p_3, 2), (p_5, 2)\}$	$Sim_m(u_t, u_2) = 2$
u_4	4	$\{(p_1, 1), (p_2, 1), (p_3, 1)\}$	$Sim_m(u_t, u_4) = 1$

Problems and user similarity score.

Maximun similarity value	
	$5 > 4 > 2 > 1$
	$u_3 > u_1 > u_2 > u_4$

Ranked $L_r = [p_1, p_2, p_5, p_4, p_3]$

Simple Voting

p_1	$1 + 1 + 1 = 3$
p_2	$1 + 1 + 1 + 1 = 4$
p_3	$1 + 1 = 2$
p_4	1
p_5	$1 + 1 = 2$

Ranked $L_r = [p_2, p_1, p_3, p_5, p_4]$

Weighted Voting

p_1	$5/12 + 4/12 + 1/12 = 0.83$
p_2	$5/12 + 4/12 + 2/12 + 1/12 = 1$
p_3	$2/12 + 1/12 = 0.25$
p_4	$4/12 = 0.33$
p_5	$5/12 + 2/12 = 0.58$

Ranked $L_r = [p_2, p_1, p_5, p_4, p_3]$

Positional Voting

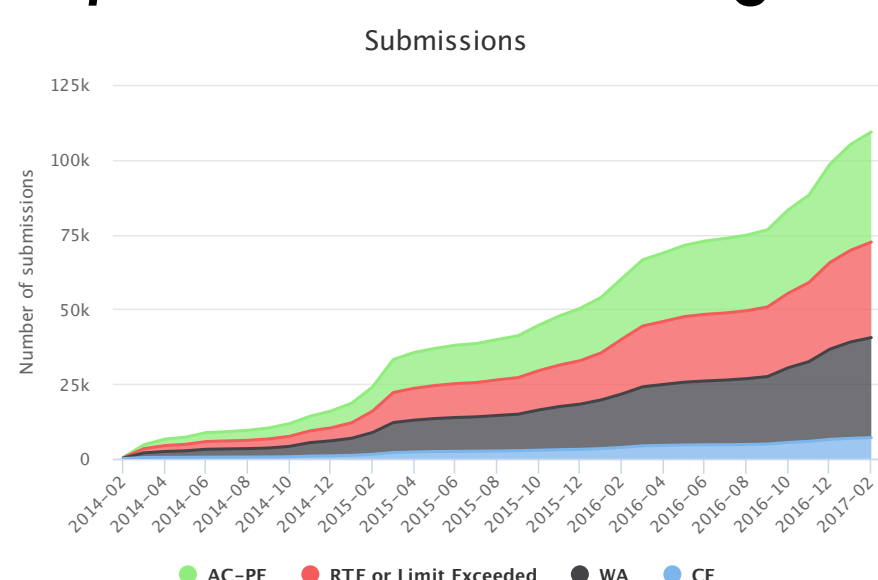| p_1	$1/1 + 1/2 + 1/4 = 1.75$
p_2	$1/1 + 1/2 + 1/3 + 1/4 = 2.08$
p_3	$1/3 + 1/4 = 0.58$
p_4	$1/2 = 0.5$
p_5	$1/1 + 1/3 = 1.33$

Ranked $L_r = [p_2, p_1, p_5, p_3, p_4]$

Evaluation

Dataset: Acepta el Reto
Acepta el Reto (ACR) or *Take On the challenge* is the online judge of the Complutense University of Madrid (UCM)
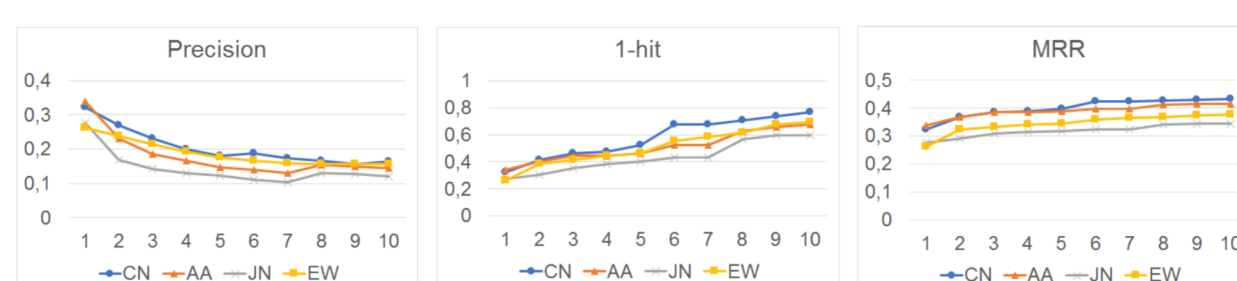
3,678 registered users
289 problems
110,000 submissions

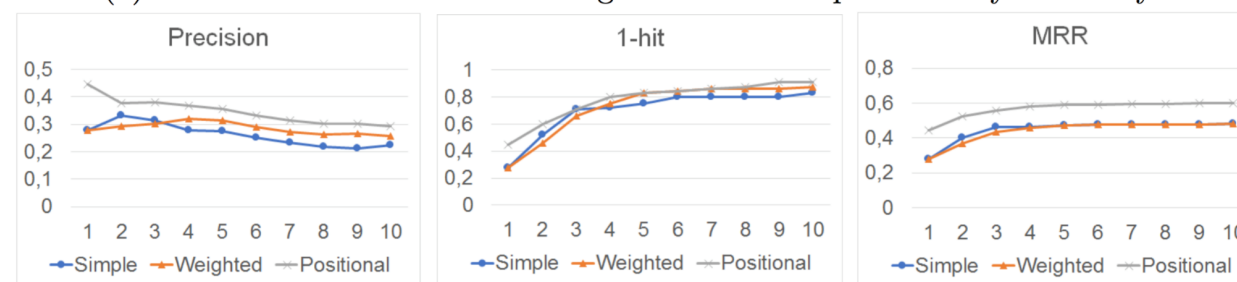**Method: Split dataset into training and test sets**

Submissions

65 users with at least 5 problems before/after time t

AC-PE   RTE or Limit Exceeded   WA   CE

Evaluation metrics: Precision, Recall, F1, 1-hit, MRR

Results

(a) User-based method and ranking recommended problems by similarity.

(b) User-based method with CN similarity, modifying the voting system.

o *Problem-based approaches using weighted metrics obtain better results than the user-based approaches using the aggregation method based on max. similarity value*

o *User-based recommendation approaches using a voting system yield better results than the problem-based approaches*

o *Number of recommended problems (k) affects the evaluation metrics*