PRIVATEJOBMATCH: A PRIVACY-ORIENTED DEFERRED MULTI-MATCH RECOMMENDER SYSTEM FOR STABLE EMPLOYMENT

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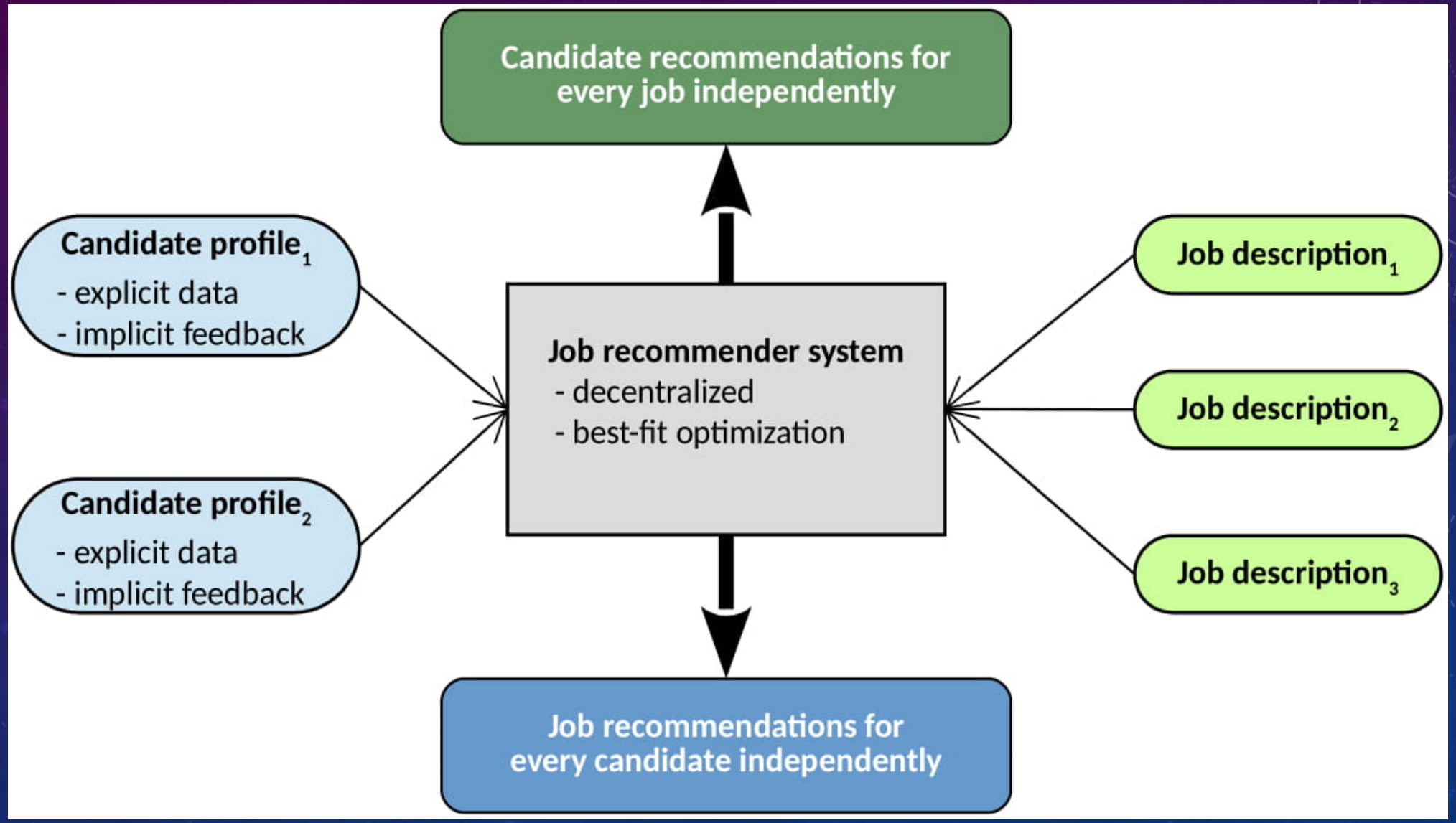
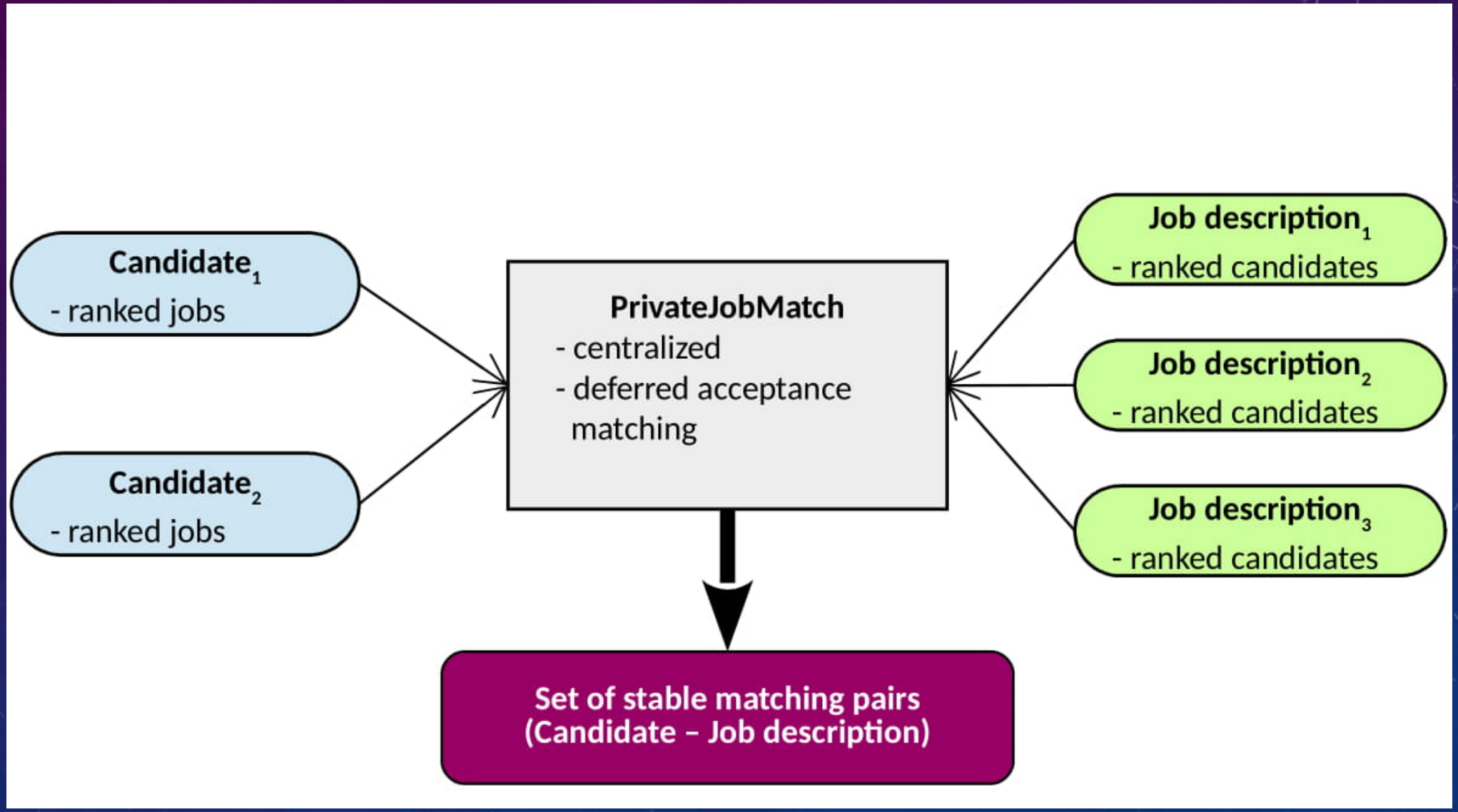
OUTLINE

1. Job Recommender Systems
2. Multi-Match Deferred Acceptance Algorithms (MMDAAs)
3. Job Market Simulation
4. Conclusion

JOB RECOMMENDER SYSTEM ARCHITECTURE



PRIVATEJOBMATCH ARCHITECTURE



CONTRIBUTIONS

- A system that only requires minimal explicit data. No need for gathering implicit data or feature selection.
- Incorporated the DAA into a recommender system that finds *multiple stable* matches between candidates and jobs as recommendations for employment, using the Multi-Match Deferred Acceptance Algorithm (MMDAA).
- Implemented machine learning techniques on the bipartisan preferences, such as Low-Rank Matrix Factorization (LMF), to enhance the resulting matches from the MMDAA. This is denoted as LMF-MMDAA.
- Our proposed Mixed MMDAA is the most efficient algorithm variation in terms of match accuracy and vacancy, which combines the MMDAA and the LMF-MMDAA.
- We run experiments over real and synthetic data with each adapted algorithm and we show that the Mixed MMDAA is the optimal algorithm based on our newly defined metrics: *Displacement*, *Withholdings*, and *Vacancy*.
- Our novel recommender system was deployed in a real application, EconMatch, with real users and found that PrivateJobMatch offers better results for maximizing job market stability, compared to a standard decentralized job market simulation.

APPLICATIONS OF DAA

One-to-One Matching Applications (Gale-Shapley DAA):

- Dating Websites
- Employment in the medical field.

Many-to-One Matching Applications (Roth-Peranson Algorithm, DAA extension):

- College Admissions

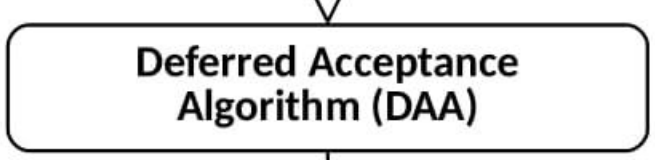
Many-to-Many Matching as Recommendations (MMDAA, proposed work):

- PrivateJobMatch

DEFERRED ACCEPTANCE ALGORITHM (DAA)

	$Rank_1$	$Rank_2$	$Rank_3$
$Candidate_1$	job_2	job_3	job_1
$Candidate_2$	job_3	job_2	job_1
$Candidate_3$	job_1	job_3	job_2

	$Rank_1$	$Rank_2$	$Rank_3$
Job_1	$candidate_3$	$candidate_1$	$candidate_2$
Job_2	$candidate_1$	$candidate_3$	$candidate_2$
Job_3	$candidate_2$	$candidate_3$	$candidate_1$



Matching pairs
$candidate_1$ <-> job_2
$candidate_2$ <-> job_3
$candidate_3$ <-> job_1

THE DAA: LIMITATIONS

- Only provides one-to-one match output.
- The DAA must meet two conditions, or the output isn't guaranteed to be one-to-one, or *stable*.
  1) Equal amount of candidates and jobs.
  2) Ranking matricies must be dense.

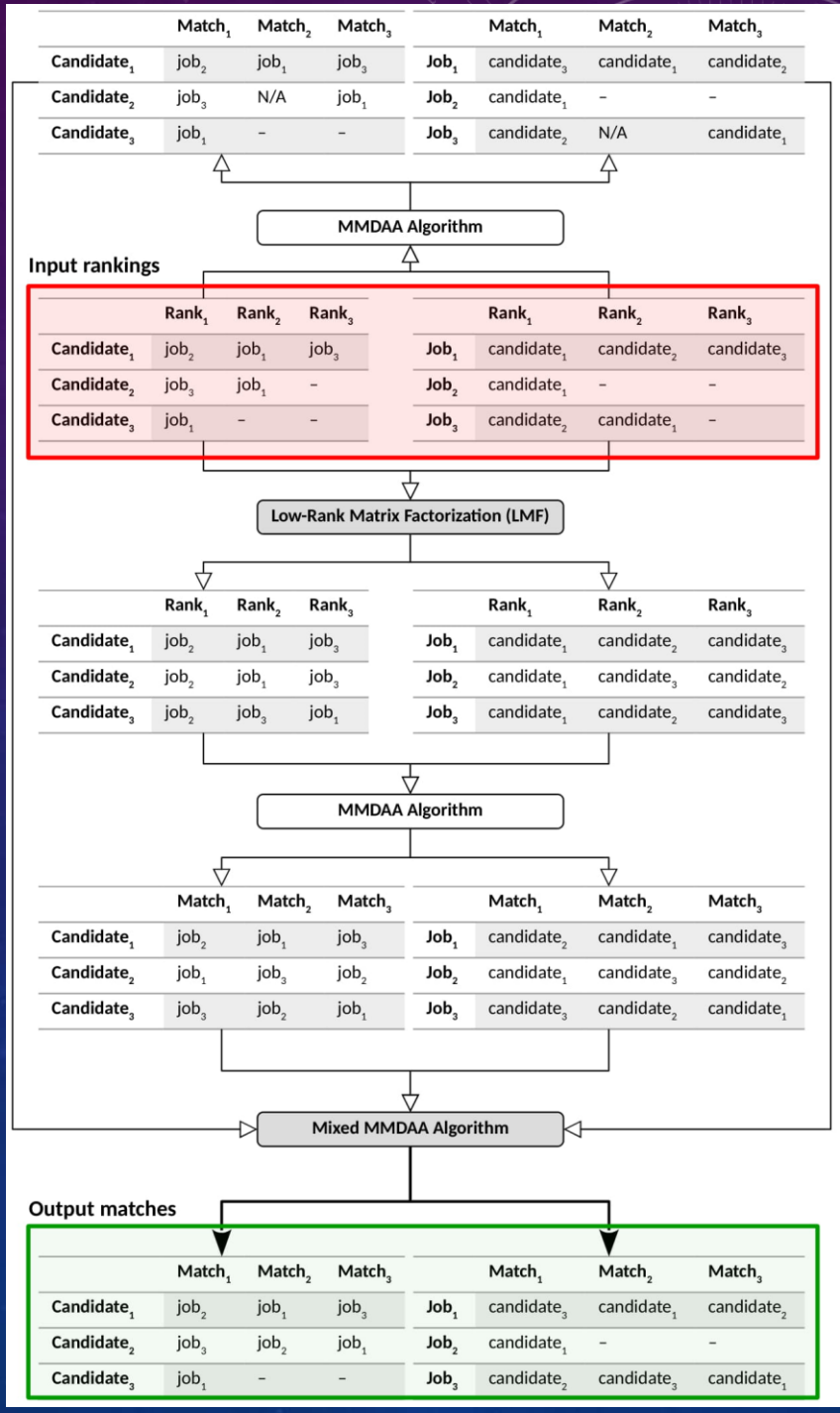
THE MIXED-MMDAA

MMDAA:

- Provides *multiple* one-to-one *stable* matches.
- While the MMDAA alleviates the restrictions of the DAA, it doesn't guarantee that everyone will get a match for each round.
- This is simply due to lack of preferences.

LMF-MMDAA

- Solves the issue of lack of preferences at the cost of match accuracy.
- While we preserve the order of the original preferences within the LMF'd preferences, there is no guarantee that the original preferences will be considered first in the MMDAA.



JOB MARKET SIMULATION

- To ensure that our system will help stabilize the job market, we created a job market simulation that measures vacancy.
- Vacancy is another metric that represents the number of jobless candidates, or unfilled job positions, after employers have offered jobs to candidates.
- Essentially, we want to simulate what would happen if
- 1) Employers offered jobs to candidates based off of their own preferences (without the use of an MMDAA, the current decentralized approach).
- 2) Employers offered jobs to candidates based off of the recommendations acquired from an MMDAA.

SIMULATION RESULTS

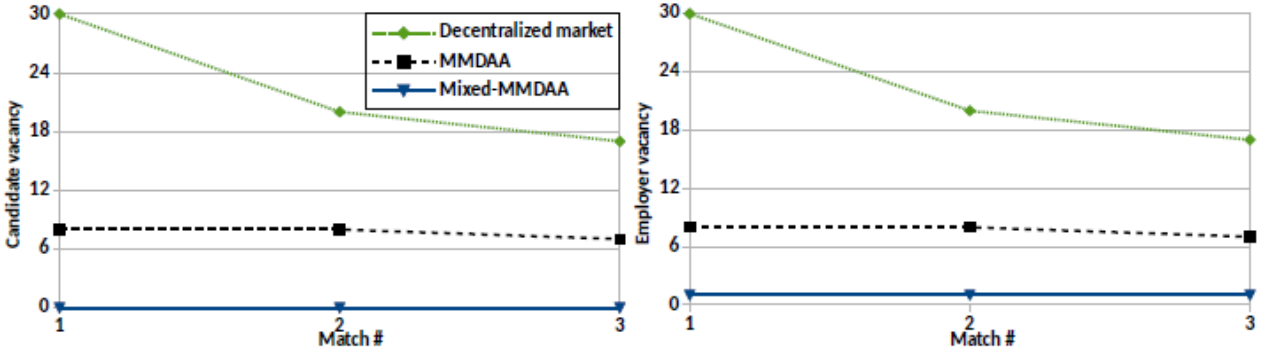


Figure 10: Vacancy on synthetic data.

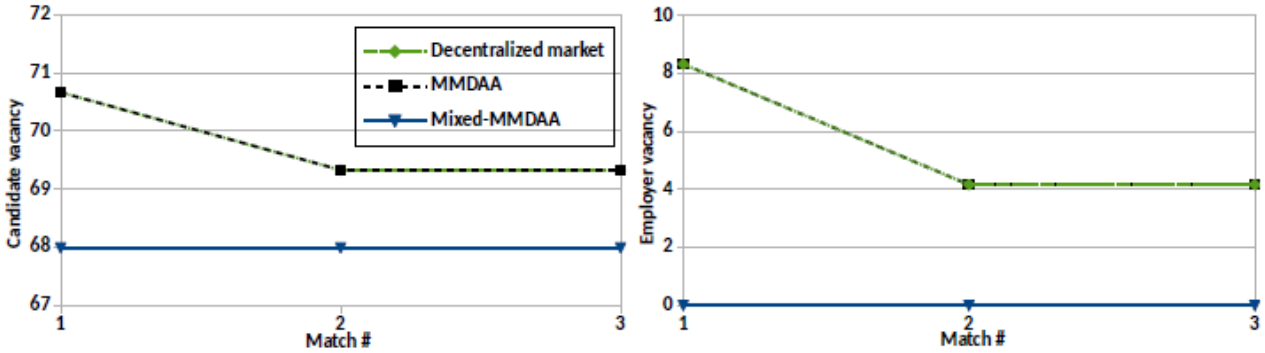


Figure 11: Vacancy on real data.

CONCLUSIONS

- Adapted the DAA into a recommender system that finds *multiple stable* matches between candidates and jobs as recommendations for employment.
- Privacy-oriented, reciprocal, no implicit data required, minimal explicit data required, no need for collaborative filtering/content-based filtering, no “cold-start” problem.
- Machine learning techniques, such as LMF, were used on the bipartisan preferences to enhance the resulting recommendations.
- The Mixed MMDAA fills in any unmatched results from the MMDAA by using the LMF-MMDAA results as substitutes, yielding the lowest average *vacancies* across all datasets.
- Deployed in an application with real users, and found that the performance is optimal compared to a standard *decentralized* job market simulation, achieving our goal of maximizing job market stability.

QUESTIONS

- PrivateJobMatch Github Repository: https://github.com/amarsaini/privatejobmatch
- Master's Thesis: https://arxiv.org/abs/1905.04564