PrivateJobMatch: A Privacy-Oriented Deferred Multi-Match Recommender System for Stable Employment

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Problem

- Coordination failure reduces match quality among employers and candidates in the job market, resulting in unstable, short-term employment.
- Generate stable pairings while requiring users to provide only a partial ranking of their preferences.
- Adaptations of the Gale-Shapley deferred acceptance algorithm which combine the flexibility of decentralized markets with the intelligence of centralized matching.
- Low-Rank Matrix Factorization/Collaborative Filtering

Algorithms

Input: Set of candidates $C = \{c_1, \ldots, c_n\}$
Set of jobs/employers $E = \{e_1, \ldots, e_n\}$
Candidate i's ranking: $RE_i = \{e_i^1, \ldots, e_i^n\}$
Job j's ranking: $RC_j = \{c_j^1, \ldots, c_j^n\}$
Init: Empty match set $M = \emptyset$

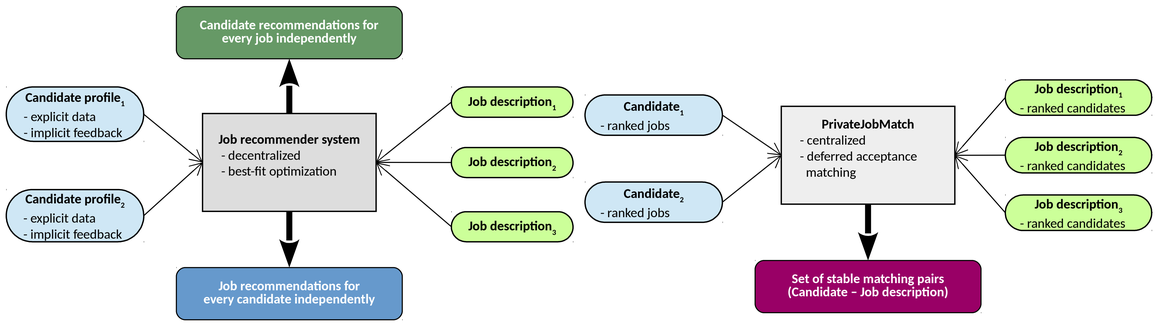
Algorithm 1: DAA Algorithm
Output: Set of matching pairs $M = \{(c_i, e_j)\}$, $c_i \in C$, $e_j \in E$

while $\exists c_i$ *with* $RE_i \neq \emptyset$ **do**
  $e_j \leftarrow RE_i.head$
  if e_j *has empty pair* **then**
    Add pair (c_i, e_j) to M
  end
  else if $\exists (c_k, e_j) \in M$ ***and*** $(RC_j[i] < RC_j[k])$ **then**
    Replace pair (c_k, e_j) with (c_i, e_j) in M
  end
end
return M

Algorithm 2: MMDAA Algorithm
Output: Ranked job matches ME_i for each candidate i
Ranked candidate matches MC_j for each job j

for $k \leftarrow 1$ ***to*** m **do**
  $M \leftarrow$ DAA(C, E, RE, RC)
  Append matches M to ME_i and MC_j
  Remove matches M from RE_i and RC_j
end
return (ME_i, MC_j)

Recommender System Architectures



DAA vs MMDAA

	Rank1	Rank2	Rank3
Candidate1	job2	job3	job1
Candidate2	job3	job2	job1
Candidate3	job1	job3	job2

	Rank1	Rank2	Rank3
Job1	candidate3	candidate1	candidate2
Job2	candidate1	candidate3	candidate2
Job3	candidate2	candidate3	candidate1

Deferred Acceptance Algorithm (DAA)

Matching pairs
candidate1 <-> job2
candidate2 <-> job3
candidate3 <-> job1

	Rank1	Rank2	Rank3
Candidate1	job2	job1	job3
Candidate2	job3	job1	–
Candidate3	job1	–	–

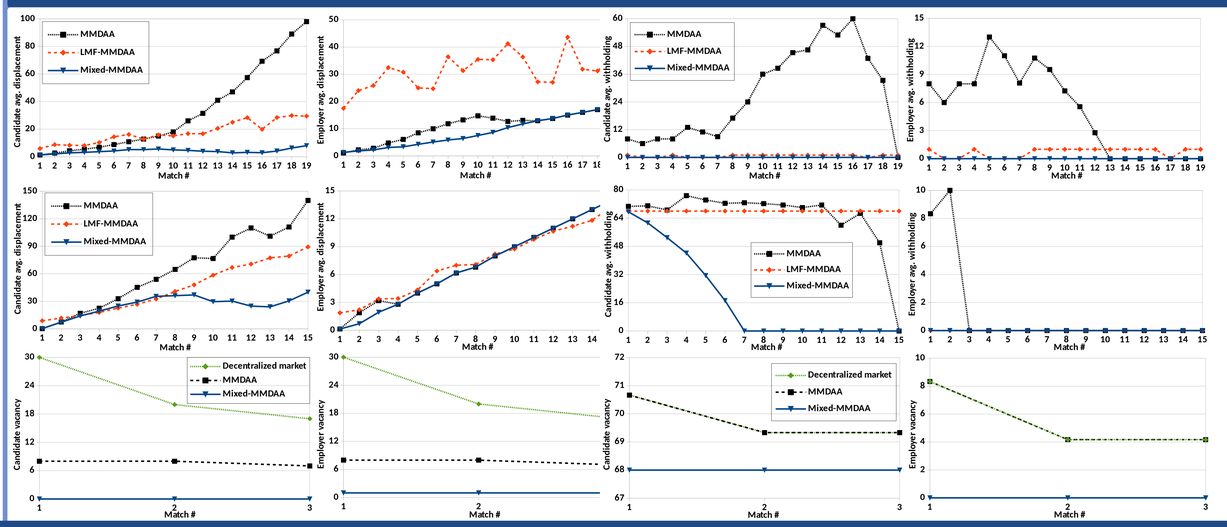
	Rank1	Rank2	Rank3
Job1	candidate1	candidate2	candidate3
Job2	candidate1	–	–
Job3	candidate2	candidate1	–

Multi-Match Deferred Acceptance Algorithm (MMDAA)

	Match1	Match2	Match3
Candidate1	job2	job1	job3
Candidate2	job3	N/A	job1
Candidate3	job1	–	–

	Match1	Match2	Match3
Job1	candidate3	candidate1	candidate2
Job2	candidate1	–	–
Job3	candidate2	N/A	candidate1

Experiments



LMF and Mixed MMDAA

Algorithm 3: Mixed MMDAA Algorithm

$RE_L \leftarrow$ LMF(RE) ▷ LMF to fill missing rankings
$RC_L \leftarrow$ LMF(RC)
$(ME_i^M, MC_j^M) \leftarrow$ MMDAA(C, E, RE, RC, m)
$(ME_i^L, MC_j^L) \leftarrow$ MMDAA(C, E, RE_L, RC_L, m)
Fill empty matches in ME_i^M with best matches from ME_i^L
Fill empty matches in MC_j^M with best matches from MC_j^L
return (ME_i^M, MC_i^M)

	Match1	Match2	Match3
Candidate1	job2	job1	job3
Candidate2	job3	N/A	job1
Candidate3	job1	–	–

	Match1	Match2	Match3
Job1	candidate3	candidate1	candidate2
Job2	candidate1	–	–
Job3	candidate2	N/A	candidate1

MMDAA Algorithm

Input rankings

	Rank1	Rank2	Rank3
Candidate1	job2	job1	job3
Candidate2	job3	job1	–
Candidate3	job1	–	–

	Rank1	Rank2	Rank3
Job1	candidate1	candidate2	candidate3
Job2	candidate1	–	–
Job3	candidate2	candidate1	–

Low-Rank Matrix Factorization (LMF)

	Rank1	Rank2	Rank3
Candidate1	job2	job1	job3
Candidate2	job2	job1	job3
Candidate3	job2	job3	job1

	Rank1	Rank2	Rank3
Job1	candidate1	candidate2	candidate3
Job2	candidate1	candidate3	candidate2
Job3	candidate1	candidate2	candidate3

MMDAA Algorithm

	Match1	Match2	Match3
Candidate1	job2	job1	job3
Candidate2	job1	job3	job2
Candidate3	job3	job2	job1

	Match1	Match2	Match3
Job1	candidate2	candidate1	candidate3
Job2	candidate1	candidate3	candidate2
Job3	candidate3	candidate2	candidate1

Mixed MMDAA Algorithm

Output matches

	Match1	Match2	Match3
Candidate1	job2	job1	job3
Candidate2	job3	job2	job1
Candidate3	job1	–	–

	Match1	Match2	Match3
Job1	candidate3	candidate1	candidate2
Job2	candidate1	–	–
Job3	candidate2	candidate3	candidate1

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