Ranking Preferences Deduction Based on Semantic Similarity for the Stable Marriage Problem

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ICCI-CC 2016 – Stanford, USA

Presentation Outline

1. The Stable Marriage Problem
2. Semantic Matching for the Job Seeking Problematic
3. Proposal: Stable Marriage Problem Using the Underlying Semantic Structure
4. Conclusion

Presentation Outline

Stable Marriage Problem

- Set of men $M = \{m_1, ..., m_n\}$;
- Set of women $W = \{w_1, ..., w_n\}$;
- A preference function π.

Preference Function π

$$\pi : \begin{cases} m \longrightarrow \langle w_a, ..., w_b \rangle & \text{a permutation of } W \\ w \longrightarrow \langle m_\alpha, ..., m_\beta \rangle & \text{a permutation of } M \end{cases}$$

Preference Function – Example

- $M = \{m_1, m_2, m_3\}$
- $W = \{w_1, w_2, w_3\}$

Preferences

Males	Females
$m_1 : w_1 > w_2 > w_3$	$w_1 : m_1 > m_2 > m_3$
$m_2 : w_2 > w_1 > w_3$	$w_2 : m_3 > m_1 > m_2$
$m_3 : w_3 > w_1 > w_2$	$w_3 : m_2 > m_1 > m_3$

Matching

$\mathfrak{M} \subset M \times W$ such that each man (resp. woman) appears in exactly one oredered pair in the set $\mathfrak{M}$.

Example for $M = \{m_1, m_2, m_3\}$ and $W = \{w_1, w_2, w_3\}$:

$$\mathfrak{M}_1 = \{(m_1, w_2), (m_2, w_3), (m_3, w_1)\}.$$

Blocking Pair

A couple $(m, w) \notin \mathfrak{M}$ such that there exists $m_x \in M$ and $w_x \in W$ such that:

- $(m, w_x) \in \mathfrak{M}$;
- $(m_x, w) \in \mathfrak{M}$;
- m prefers w over his partner;
- w prefers m over her partner.

Blocking Pair – Example

Preferences

Males	Females
$m_1 : w_1 > w_2 > w_3$	$w_1 : m_1 > m_2 > m_3$
$m_2 : w_2 > w_1 > w_3$	$w_2 : m_3 > m_1 > m_2$
$m_3 : w_3 > w_1 > w_2$	$w_3 : m_2 > m_1 > m_3$

$$\mathfrak{M}_1 = \{(m_1, w_2), (m_2, w_3), (m_3, w_1)\}$$

(m_1, w_1) is a blocking pair for $\mathfrak{M}_1$ because:

- m_1 prefers w_1 over w_2;
- w_1 prefers m_1 over m_3.

Definition: A matching $\mathfrak{M}$ is stable if there is no blocking pair for $\mathfrak{M}$.

Stable Matching – Example

Preferences

Males	Females
$m_1 : w_1 > w_2 > w_3$	$w_1 : m_1 > m_2 > m_3$
$m_2 : w_2 > w_1 > w_3$	$w_2 : m_3 > m_1 > m_2$
$m_3 : w_3 > w_1 > w_2$	$w_3 : m_2 > m_1 > m_3$

$$\mathfrak{M}_2 = \{(m_1, w_1), (m_2, w_2), (m_3, w_3)\}.$$

$\mathfrak{M}_2$ is stable.

Classical Results [Shapley & Gale 1962]

procedure GALE-SHAPLEY(The sets M and W of resp. the men and the women)
    while there is a bachelor man m **do**
        $w \leftarrow$ the first woman in $\pi(m)$ to which m has not yet proposed;
        if w is single **then**
            match m with w;
        else if $m' <_w m$ where m' is w's current partner **then**
            match m with w and set m' bachelor;
        else
            w rejects m and m remains bachelor;
        end if
    end while
end procedure

Classical Results [Shapley & Gale 1962]

Theorem: The Gale-Shapley algorithm computes a stable matching in $O(n^2)$-time (man-optimal and woman-pessimal).

Corollary: For any instance of the Stable Marriage Problem, there exists a stable matching.

The Compact Stable Marriage Problem

- Using a compact preference formalism as input for the Stable Marriage Problem.
- Introduced by [Pilotto-al 09] using CP-nets.
- Modification of the primitives of the resolution algorithm.
- CP-nets may be not so natural.

Presentation Outline

The Job Seeking/Recruitment Problem

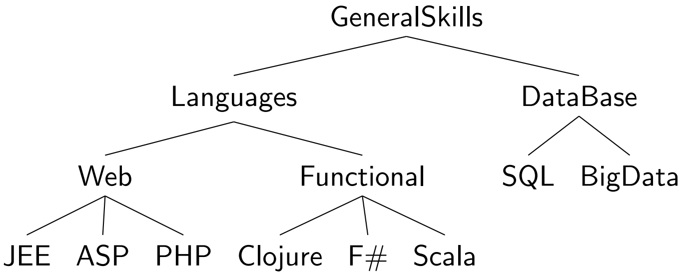
Goal:

- Retrieve a list of job positions to a job applicant based on his/her preferences;
- Generate a list of job candidates to a recruiter based on the job requirements.

Resolution [Zhong-al 02] and [Bizer-al 05]

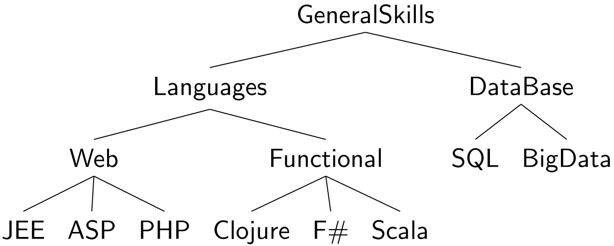
- Profiles of the actors using concepts from a taxonomy.
- Semantic Ranking using this taxonomy.

Example of a Taxononomy (Skills Hierarchy)



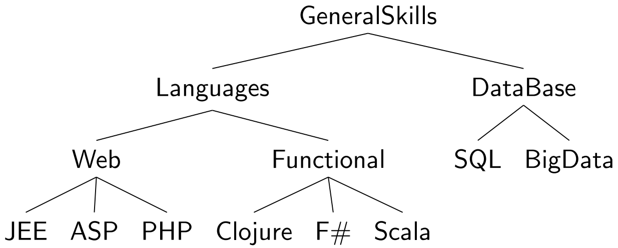
Profiles

$r = [ASP, BigData]$
$s_1 = [JEE, SQL]$
$s_2 = [Scala, BigData]$



Weighted Profiles

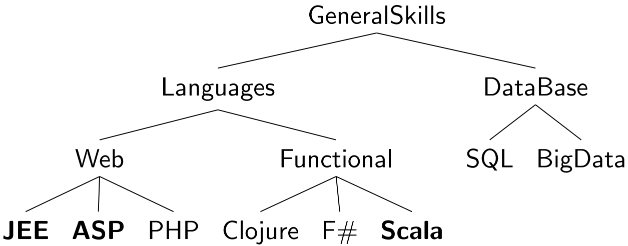
$r = [(ASP, 0.7),\ (BigData, 0.3)]$
$s_1 = [(JEE, 0.5),\ (SQL, 0.5)]$
$s_2 = [(Scala, 0.5),\ (BigData, 0.5)]$



Semantic Similarity

$$sim_c(c_1, c_2) = 1 - d_c(c_1, c_2)$$

$$sim_c(ASP, JEE) = 1 - d_c(ASP, JEE) = \frac{7}{8}$$
$$sim_c(ASP, Scala) = 1 - d_c(ASP, Scala) = \frac{5}{8}$$

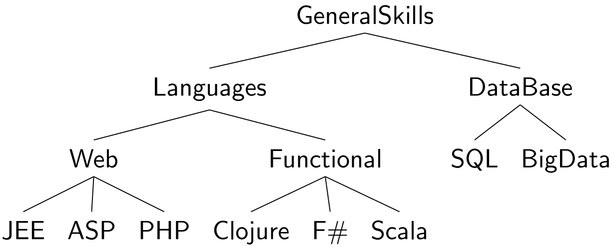


Semantic Distance

$$sim_c(c_1, c_2) = 1 - d_c(c_1, c_2)$$

$$d_c(c_1, c_2) = d_c(c_1, cpp) + d_c(c_2, cpp)$$
$$d_c(c_x, cpp) = milestone(cpp) - milestone(c_x)$$

$$milestone(c_x) = \frac{1}{2k^{level(c_x)}}$$



Competence Level Similarity

$$sim_p(cl_1, cl_2) = \begin{cases} 1 - \alpha(cl_1 - cl_2) & \text{if } cl_1 > cl_2 \\ 1 & \text{otherwise} \end{cases}$$

where $0 \leq \alpha \leq \frac{1}{4}$

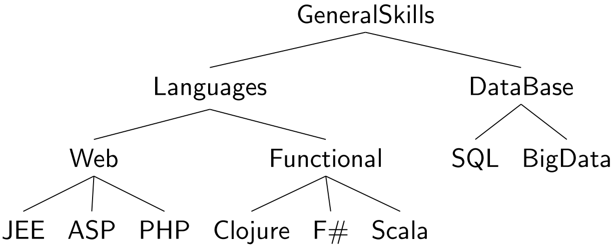
Global Similarity of Two Profiles

$$Sim(r,s) = \sum_i w(r_i).\max_j\{sim_c(r_i,s_j).sim_p(p_{r_i},p_{s_j})\}$$

where $\sum_i w(r_i) = 1$

Global Similarity of Two Profiles

$$r = [(ASP, 0.7),\ (BigData, 0.3)]$$
$$s_1 = [(JEE, 0.5),\ (SQL, 0.5)] \dashrightarrow Sim(r, s_1) \simeq 0.82$$
$$s_2 = [(Scala, 0.5),\ (BigData, 0.5)] \dashrightarrow Sim(r, s_2) \simeq 0.72$$



Presentation Outline

Proposal: Semantic Stable Marriage Problem

Derive the choices of the agents (men and women) without that these ones have actually given explicitly their choices.
$\rightarrow$ Using the underlying semantic structure.

Extending the metaphor of the “marriage”

- Consider another problem: the Dating Problem.
- $\hookrightarrow$ Goal: give a ranking over the other sex’s members.
- $\hookrightarrow$ This output provides an input to the Stable Marriage Problem.

Here we consider the resolution, previously exposed, of the Job Seeking Problem (similar to the Dating Problem).

Preprocessing Using the Semantic Similarity

- Operate a preprocessing (to obtain the ranks) over the actors before running the Gale-Shapley Algorithm.
- To do this we have to consider a ranking measure, based on the semantic similarity measure *Sim* defined in the state of the art of the Job Seeking Problem resolution.

Preprocessing Using the Semantic Similarity

procedure GALE-SHAPLEY_WITH_PREPROCESSED_RANKING(The sets M and W of resp. the men and the women)

    // Find the preferences

    for $m \in M$ **do**

        $\pi(m) \leftarrow$ rank the women in W following Sim_m;

    end for

    for $w \in W$ **do**

        $\pi(w) \leftarrow$ rank the men in M following Sim_w;

    end for

    Gale-Shapley(M, W);

end procedure

Presentation Outline

Conclusion

- An method to resolve the Compact Stable Marriage Problem using a semantic approach.
- $\rightarrow$ Simple approach.
- $\rightarrow$ Allow a convenient way to resolve the Stable Marriage Problem.

Future Work

- Study of the Stable Marriage Problem variants.
- A "better" similarity measure using a different type of taxonomy.