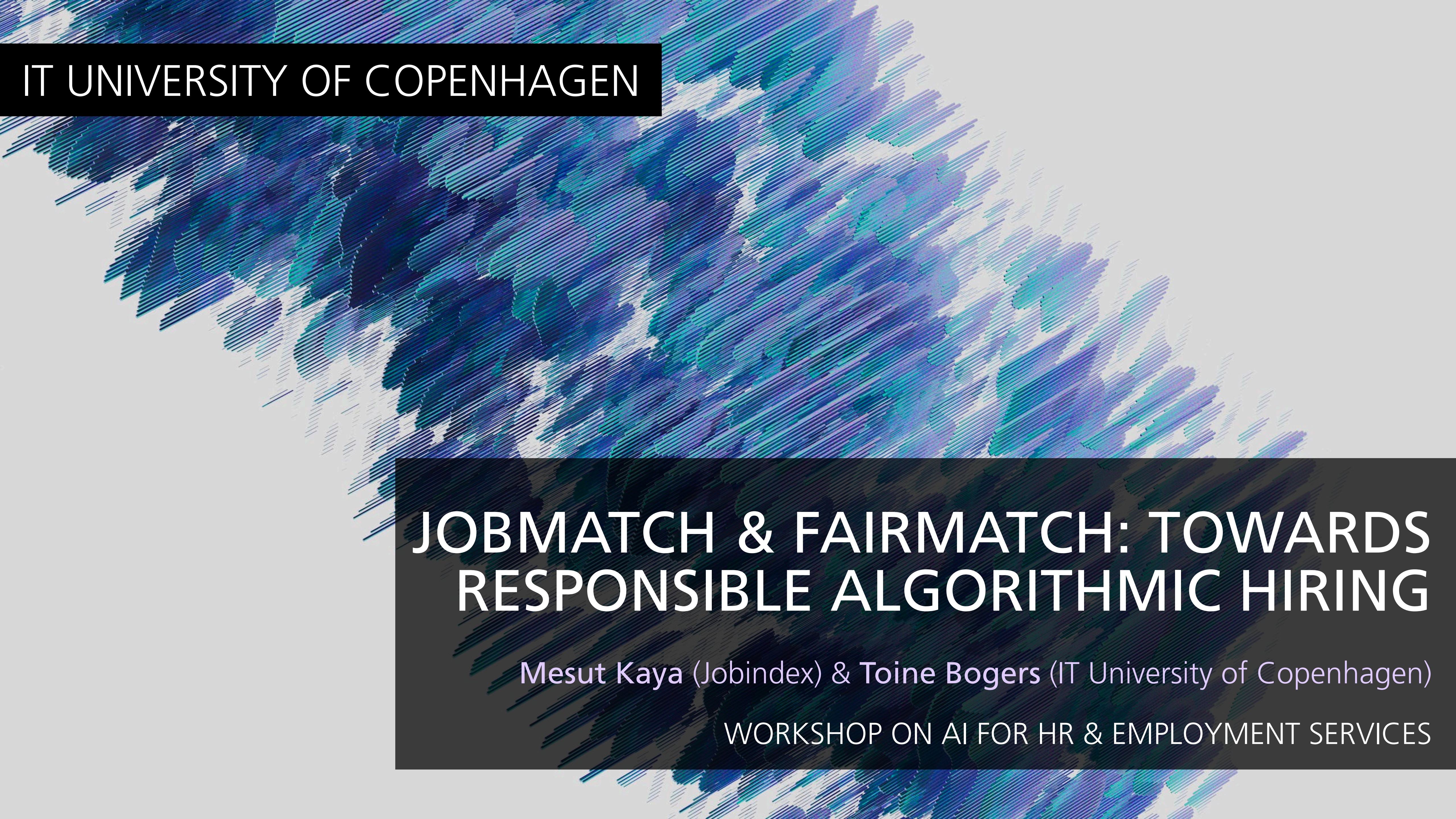




IT UNIVERSITY OF COPENHAGEN

JOBMATCH & FAIRMATCH: TOWARDS RESPONSIBLE ALGORITHMIC HIRING

Mesut Kaya (Jobindex) & Toine Bogers (IT University of Copenhagen)

WORKSHOP ON AI FOR HR & EMPLOYMENT SERVICES

- ▶ Introduction
- ▶ **Jobmatch** project (2020-2023)
- ▶ **Fairmatch** project (2024-2027)



PART 1

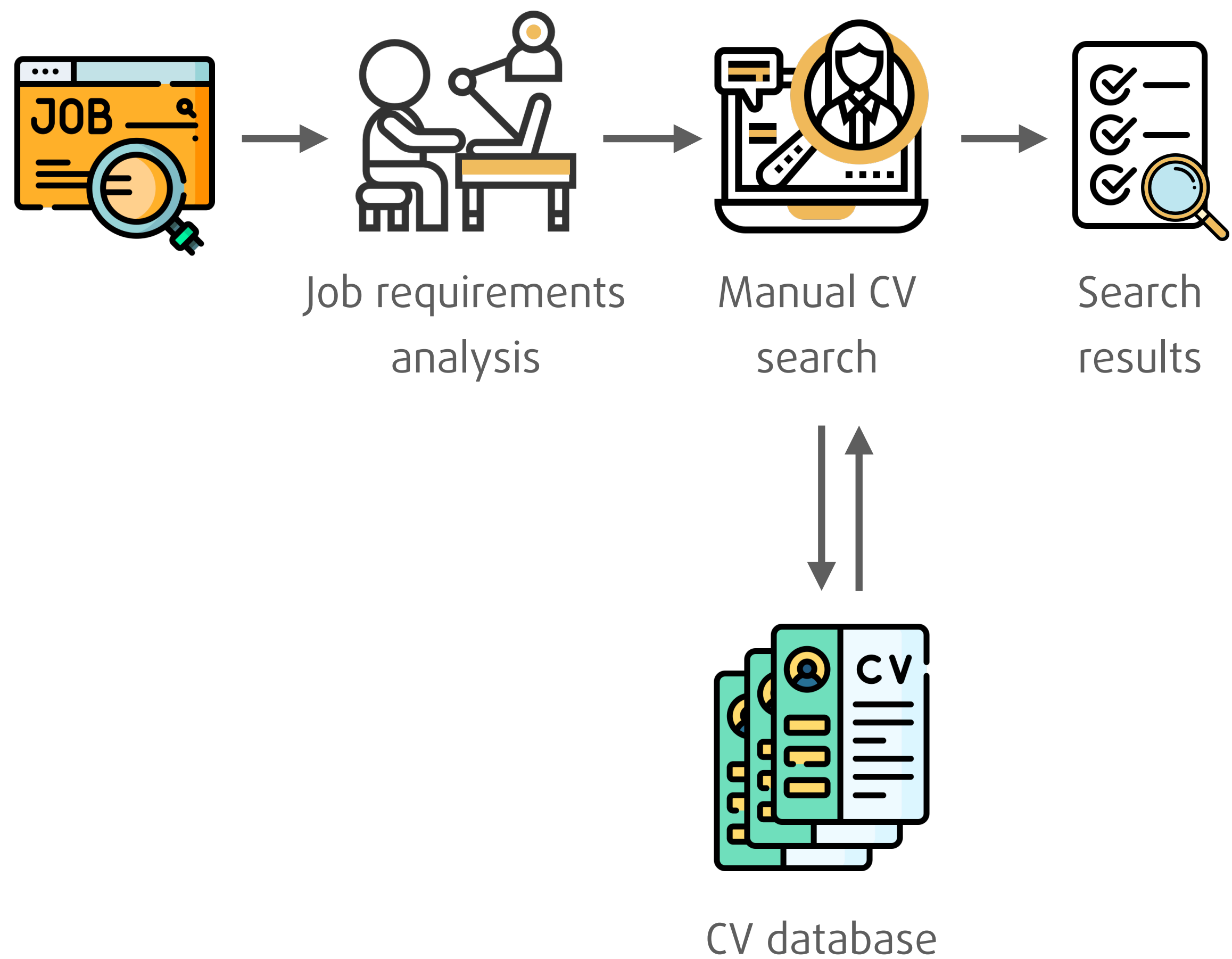
Introduction

- ▶ Academic-industrial collaboration with **Jobindex**
 - Denmark's biggest job portal (>30K job postings, >120K resumés, >600 unique users)
- ▶ Two projects
 - **Jobmatch** (2020-2023)
 - Supporting recruiters (i.e., candidate recommendation)
 - **Fairmatch** (2024-2027)
 - Fair algorithmic hiring (both candidate and job recommendation)

Jobindex

HOW DO JOBINDEX RECRUITERS WORK?

8



1

Search in CVs

sales supply chain

Choose job titles

Search

Enter work location (e.g. postcode or city)

Choose category/categories

Reset

2

Filter your search

Following company

☐ Testfirma

Education level

At least

Maximum

Work experience (years)

10

Maximum

Management experience (years)

5

Maximum

Salary expectations

40,000 kr.

60,000 kr.

Tags

Advanced

Language skills

English

Minimum language proficiency

3

Found 1,845 users.

Contact CVs

Clear CVs

Sent me

Language skills

English

Management experience

5–

Notice period

1 month notice

Salary expectations

40,000 kr.–60,000 kr.

Search among

Online CVs + followers

Search term

sales supply chain

Special groups

Full-time

Work experience

10–

Create CV Agent

Experienced Supply Chain Management Professional

Job wishes: Supply Chain Director, Category Manager, COO, Director and 6 others

Latest job: Owner and founder

Geography:

Education: Graduate Diploma in Business Administration) – HD 2. Supply Chain Management

Salary expectations: DKK 40-50,000

Work experience: 24 years

Conditions of employment: Full-time and temp

Management experience: 20 years

Experienced Supply Chain Management Professional – with extensive international leadership experience from Strategic Sourcing, Procurement, Supply Chain Management, Product Portfolio Management, Business & Product Development and leading global international teams.

... one of the best managers within Supply Chain and Procurement in Denmark ...

... PROFILE I am an Experienced Supply Chain Management Professional with a solid ...

supply shipment

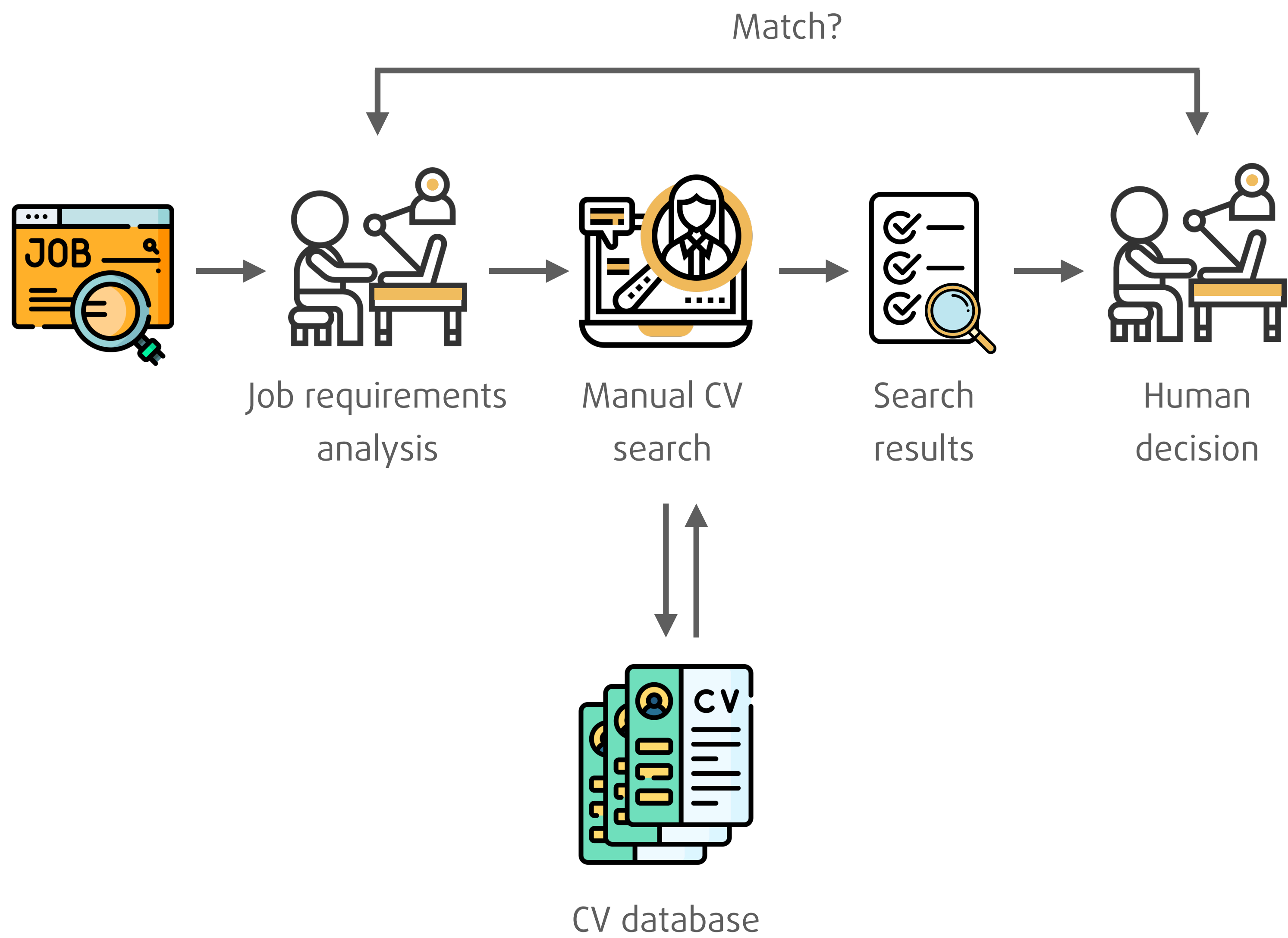
Experienced Supply Chain Management Professional

Global Supply Chain Jobs

ABC

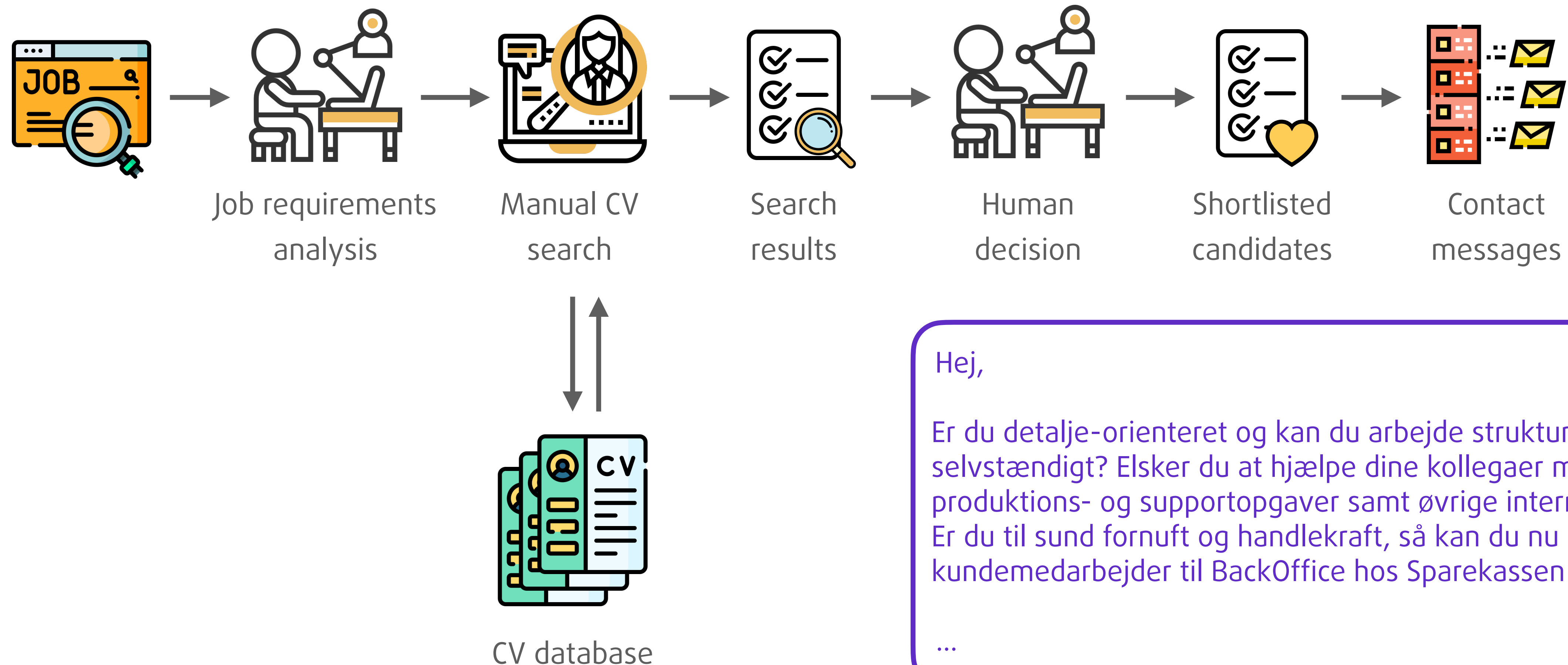
+ 134 others

HOW DO JOBINDEX RECRUITERS WORK?



HOW DO JOBINDEX RECRUITERS WORK?

11

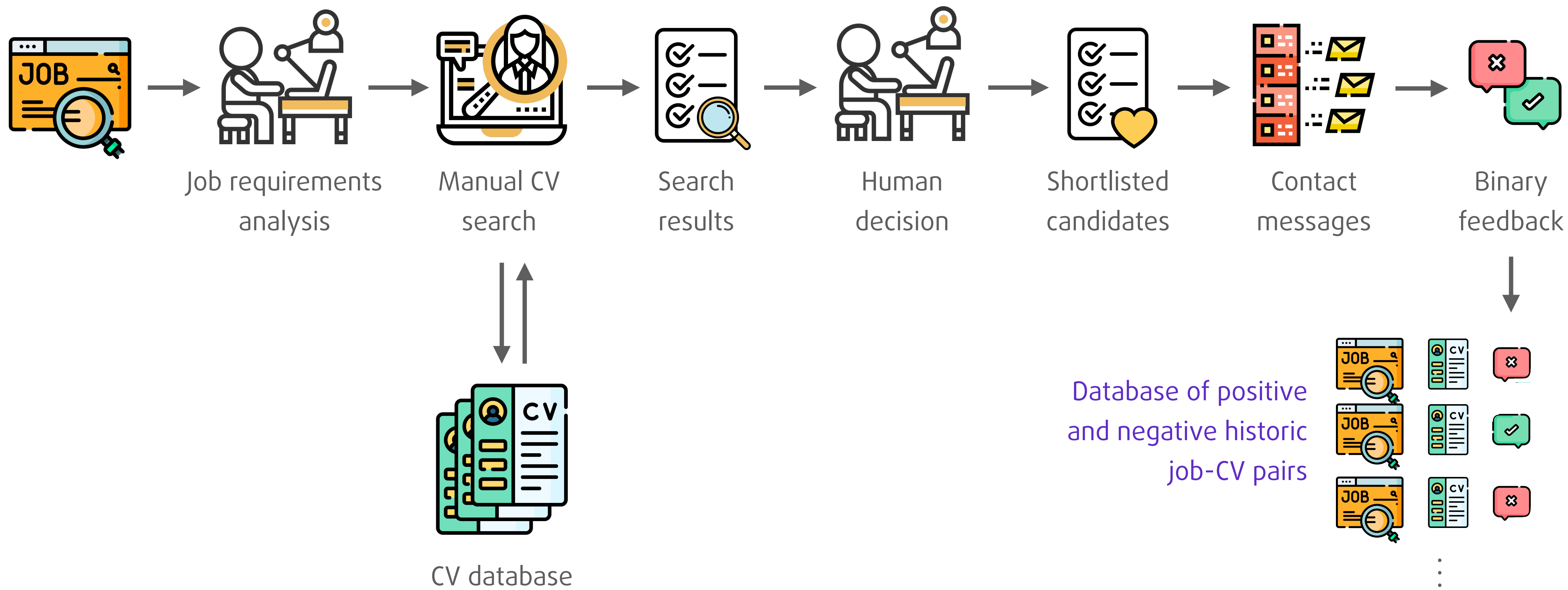


Hej,

Er du detalje-orienteret og kan du arbejde struktureret og selvstændigt? Elsker du at hjælpe dine kollegaer med produktions- og supportopgaver samt øvrige interne opgaver? Er du til sund fornuft og handlekraft, så kan du nu blive kundemedarbejder til BackOffice hos Sparekassen Danmark A/S.

...

HOW DO JOBINDEX RECRUITERS WORK?





PART 2

Jobmatch

► Jobmatch project

- Three-year research project from Innovation Fund Denmark with two post-docs (Mesut Kaya and Qiuchi Li)
 - Collaboration between University of Copenhagen, Aalborg University and Jobindex
- Goal is to **support Jobindex' recruiters** in their work matching candidates to jobs

Jobindex

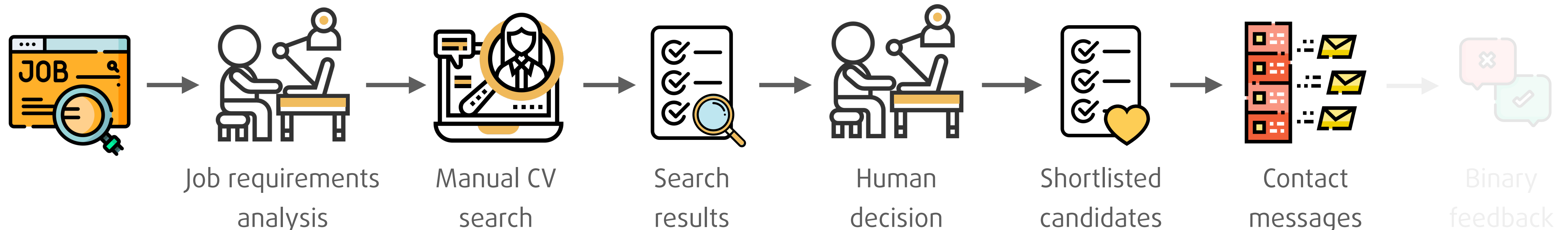
► Supporting the recruiters means **understanding how they work**

– **Qualitative** study of recruiters' work processes

- 12 contextual inquiry sessions ($\approx$ mix of observation and interview)
- 1 focus group

– **Quantitative** study of recruiters' search logs

- Analysis of 157,046 search sessions (queries, contacted candidates, responses)



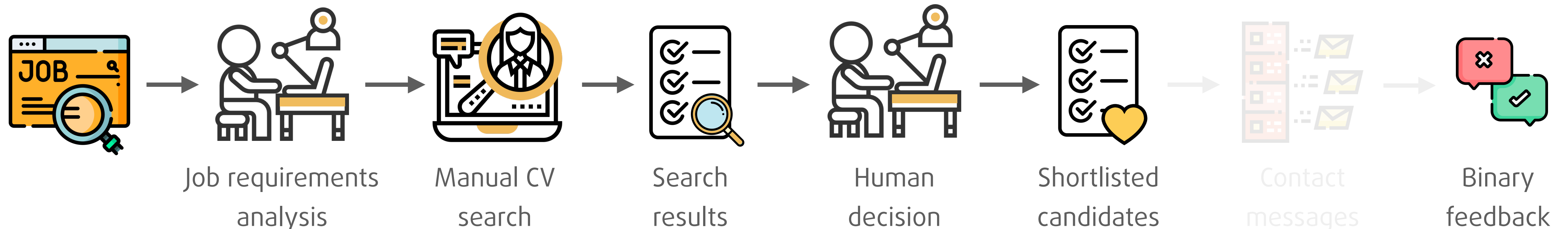
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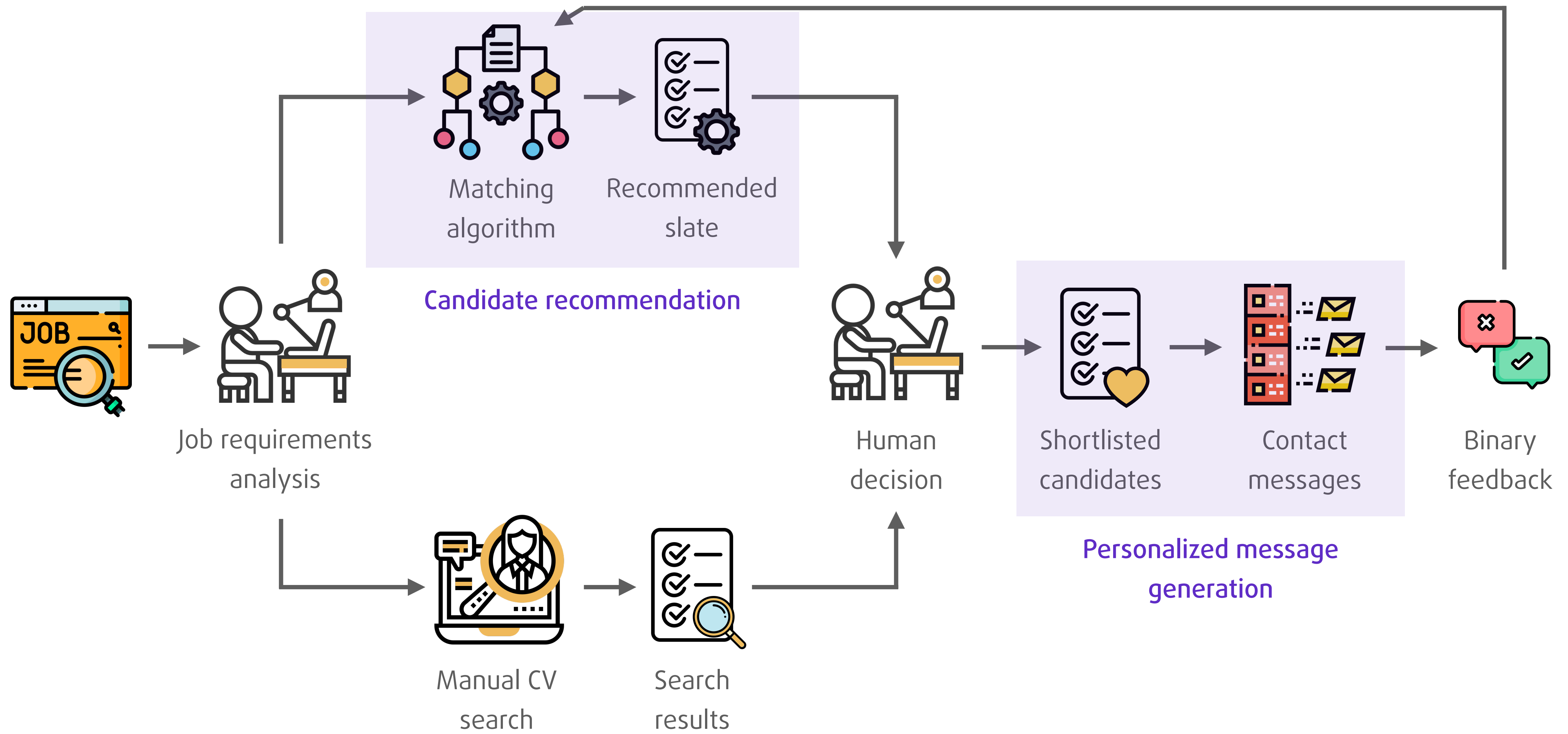
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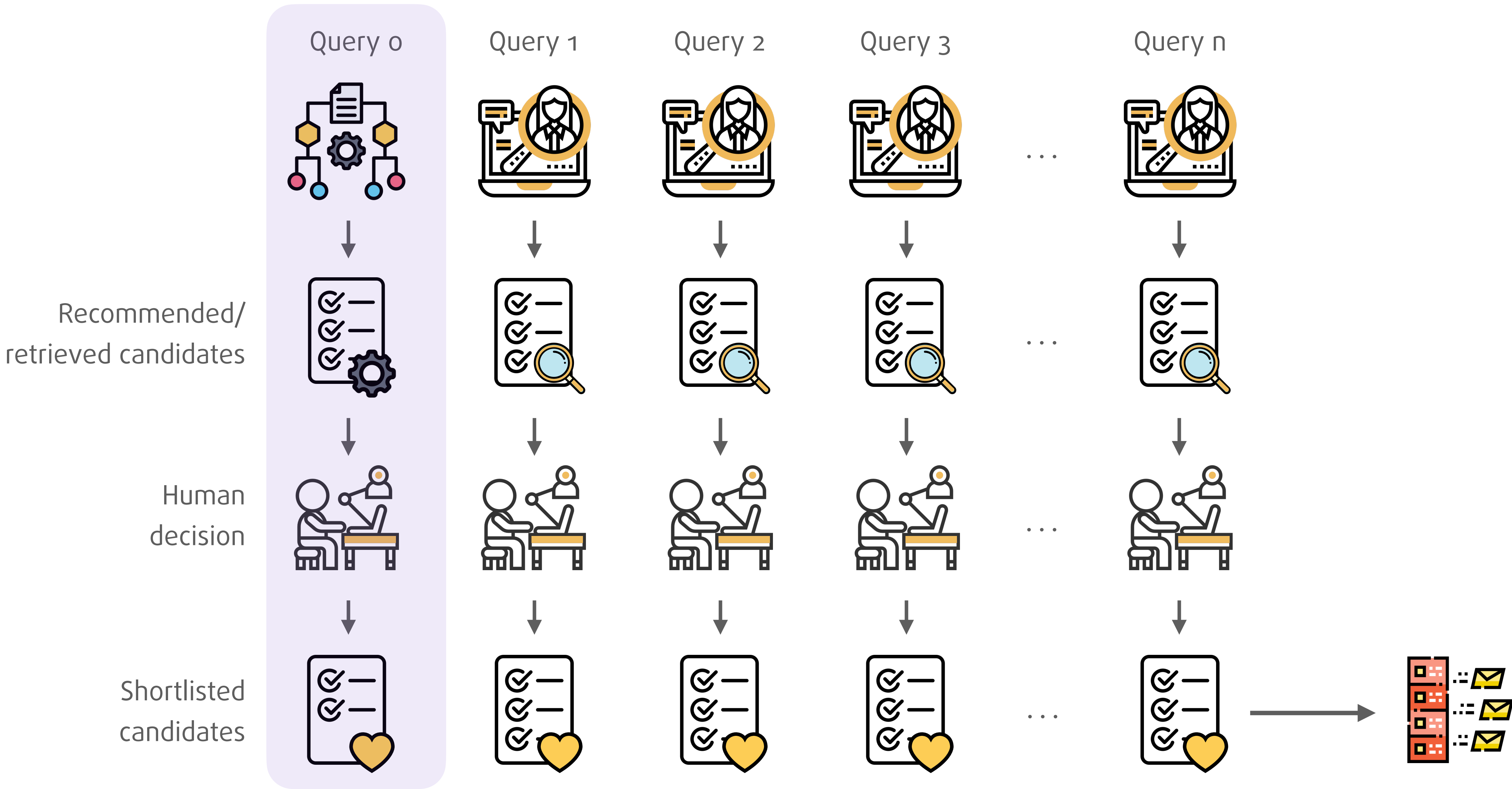
► Findings

- Recruiters focus on **primary qualifications** (= skills & competences) and past/current **job titles**
- Search results can serve as source of new search terms
- Commonly used **filters** include **salary** and **years of work/management experience**
- Relevance assessed using **1-3 most recent work experiences** and matches on **qualifications**
- Strong reliance on **highlighting in the results list**
- First 10 candidates are low-hanging fruit, **next 10 candidates require more time and effort**
- **Time per query, use of filters and query complexity** all increase throughout the sessions
- Caveat: no clickstream data → we are analyzing a richer search log for future work

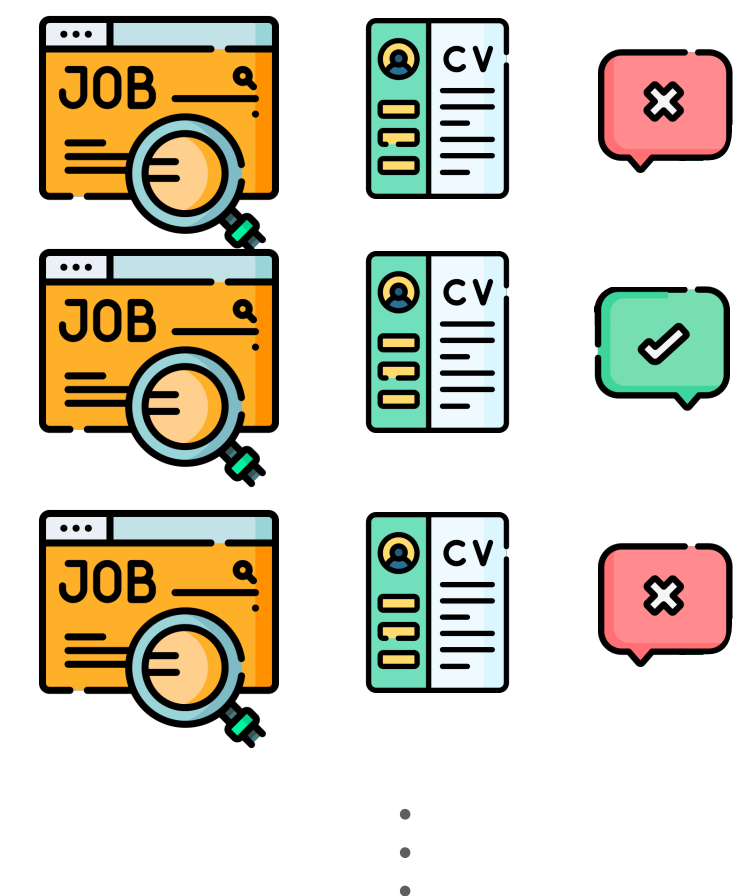
CANDIDATE RECOMMENDATION



CANDIDATE RECOMMENDATION

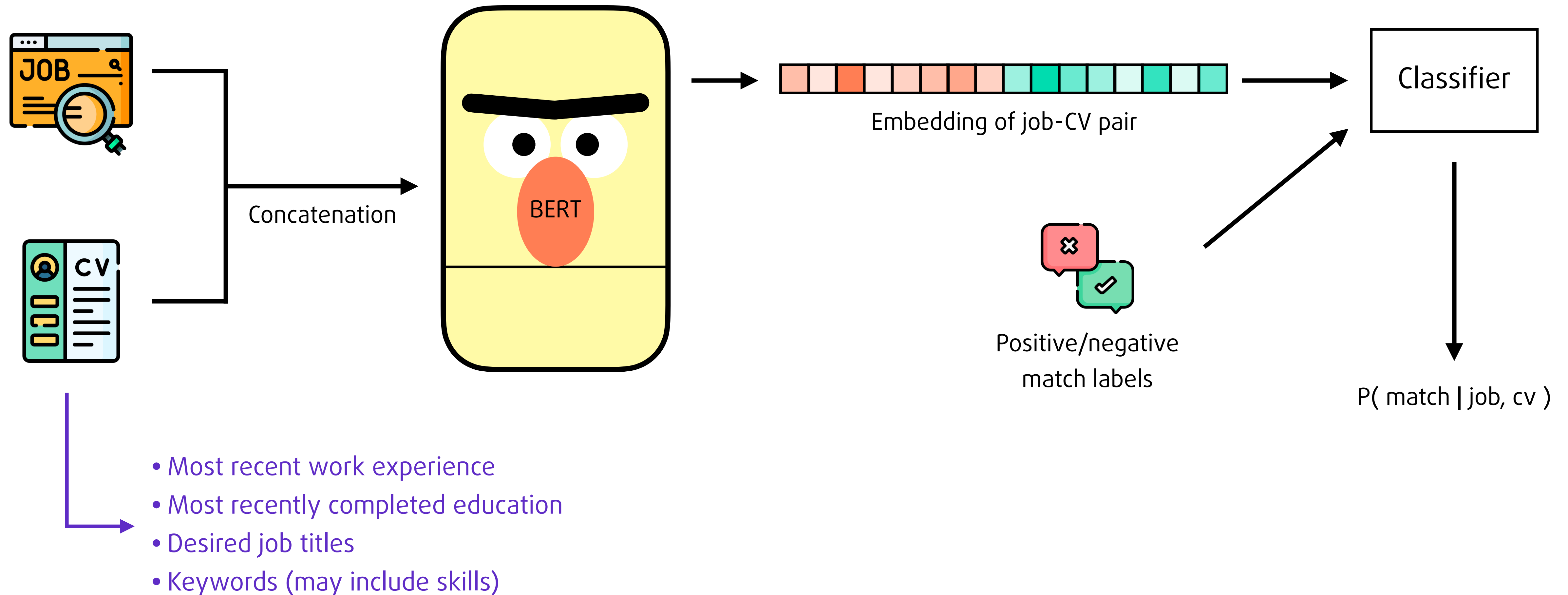


- ▶ Goal is to **support recruiters with recommendations** instead of replacing them
 - Relevant recommendations should result in **shorter sessions** and more efficient recruiters
- ▶ Algorithm development
 - **Collaborative filtering** baselines → using past interactions between job seekers and job ads (“People who applied for job X also applied for this job”)
 - Item-based k-Nearest Neighbor
 - Bayesian Personalized Ranking
 - Problems: **cold start** (each job is new!) and **data sparsity** (few interactions!)



- ▶ **Content-based filtering** → using semantic representations of jobs and CVs to match them
 - Generated **embeddings** of job ads and CVs using **word2vec**, **doc2vec**, and (Danish) **BERT**
 - Pre-trained as well as **fine-tuned** on ~260,000 CVs and ~426,000 job ads
 - Standard matching between job ad and CV embeddings using **FAISS** library
 - Development iterations
 - **Iteration 1:** Full-text embeddings vs. embedding **only job titles**
 - **Iteration 2:** Hybrid algorithm that **incorporates the interaction history** embedding of job titles only
 - ★ A CV is represented by the average of all job (embeddings) they interacted with
 - ★ A job is represented by the average of all CV (embeddings) that interacted with it (**cold start issue**)

- **Iteration 3:** Matching CVs and jobs using **sentence-pair classification**

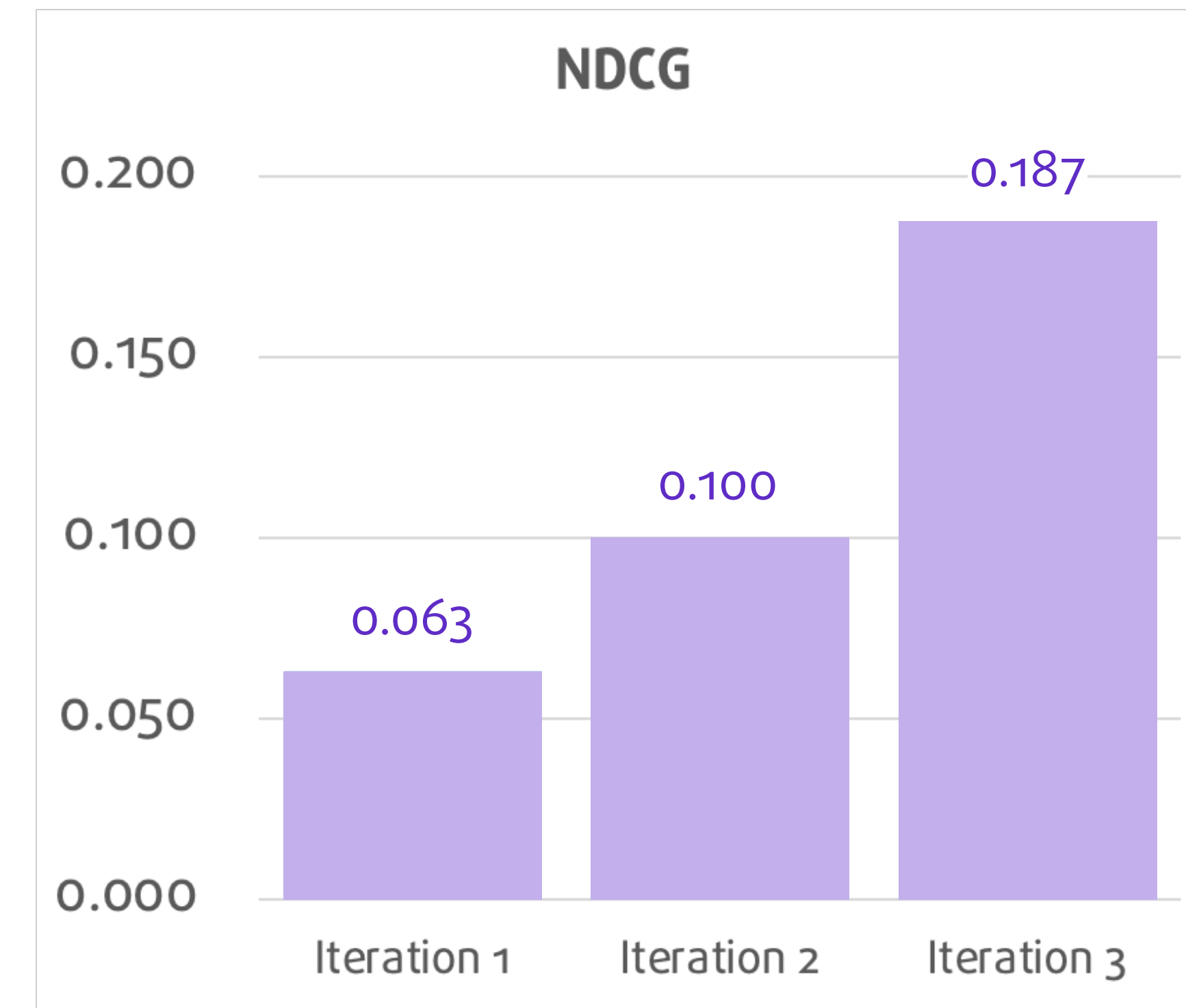


► **Offline** evaluation

- Iteration 3 outperforms the existing prototypes by a wide margin

► **Online** evaluation (of iteration 3, April-Nov 2023)

- **11.5% higher response rate** when viewing the list of recommendations
- **12.8% fewer queries** submitted
- Around **8 out of 23** candidates to be contacted are in the list of recommendations
- **Lots of effort** went into implementing A/B testing infrastructure at Jobindex



► Lessons learned

- Habits can be **hard to break** (~40% ignore the recommendations)
- **Communication** and **involvement** is key! (fear of being replaced vs. lack of trust)
- ~~Check Double-check~~ **Triple-check for bugs!**
- **Pre-filtering the candidate set** is useful to **offset** costly sentence-pair classification
- Important (sometimes impossible?) to **coordinate A/B tests with other departments**
- Success **partially** depends on **external factors**



PART 3

Fairmatch

► Fairmatch project

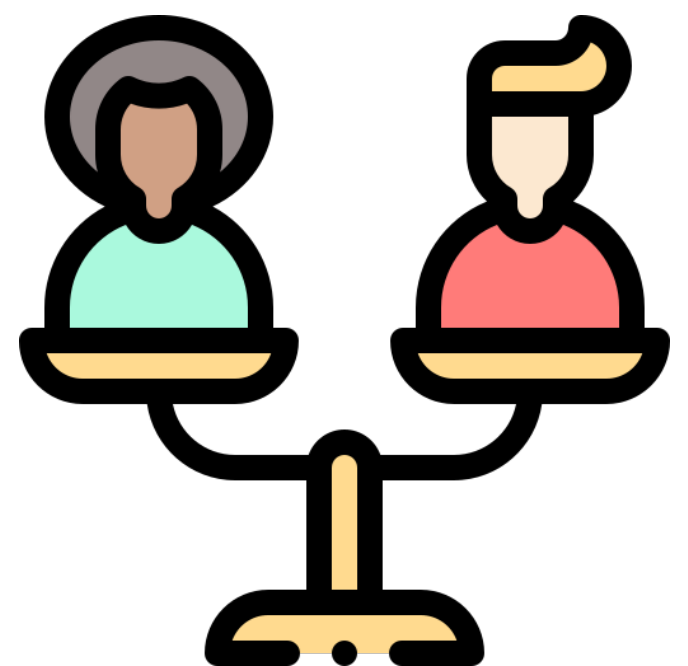
- Three-year industrial postdoc grant from Innovation Fund Denmark
- Collaboration between IT University of Copenhagen and Jobindex

► Goal

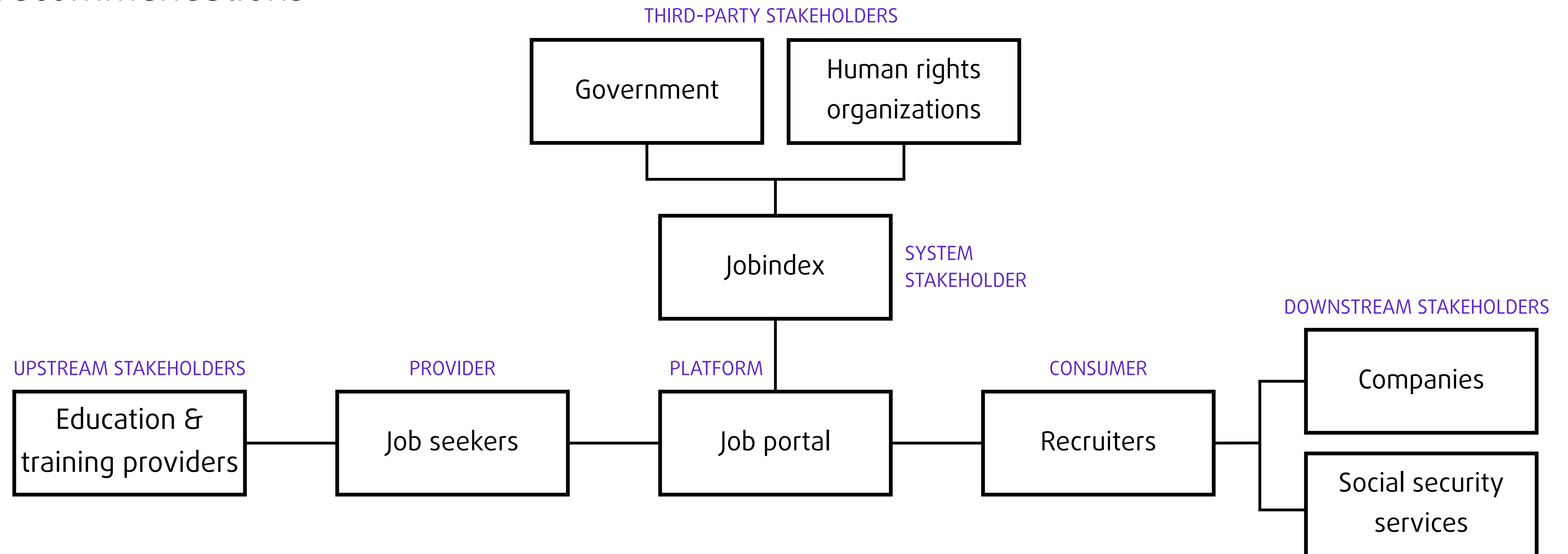
- Making Jobindex's **algorithmic hiring infrastructure** more **fair** to aid them in complying with the **EU AI Act**

► What does **fairness** mean in algorithmic hiring?

- Individual fairness? Group fairness? Which sensitive attributes are important?
- Different stakeholders may have different notions of fairness!
- How should we mitigate unfairness?



- ▶ Algorithmic hiring is a key example of **multi-stakeholder** recommendation:
 - All stakeholders have their **own interests** that should be considered when generating recommendations



1. Mapping Stakeholder Needs to Fairness Metrics

- ▶ Qualitative research on stakeholder needs and notions of fairness, mapped to relevant fairness metrics

2. Auditing Algorithmic Hiring through a Fairness Dashboard

- ▶ Develop an algorithmic auditing framework supported by a dashboard to analyze fairness metrics

3. Fair candidate recommendation

- ▶ Developing fairness-aware candidate recommendation algorithms

4. Fair job recommendation

- ▶ Developing fairness-aware job recommendation algorithms

5. Industrial Integration

- ▶ Integrating developed solutions into Jobindex' infrastructure

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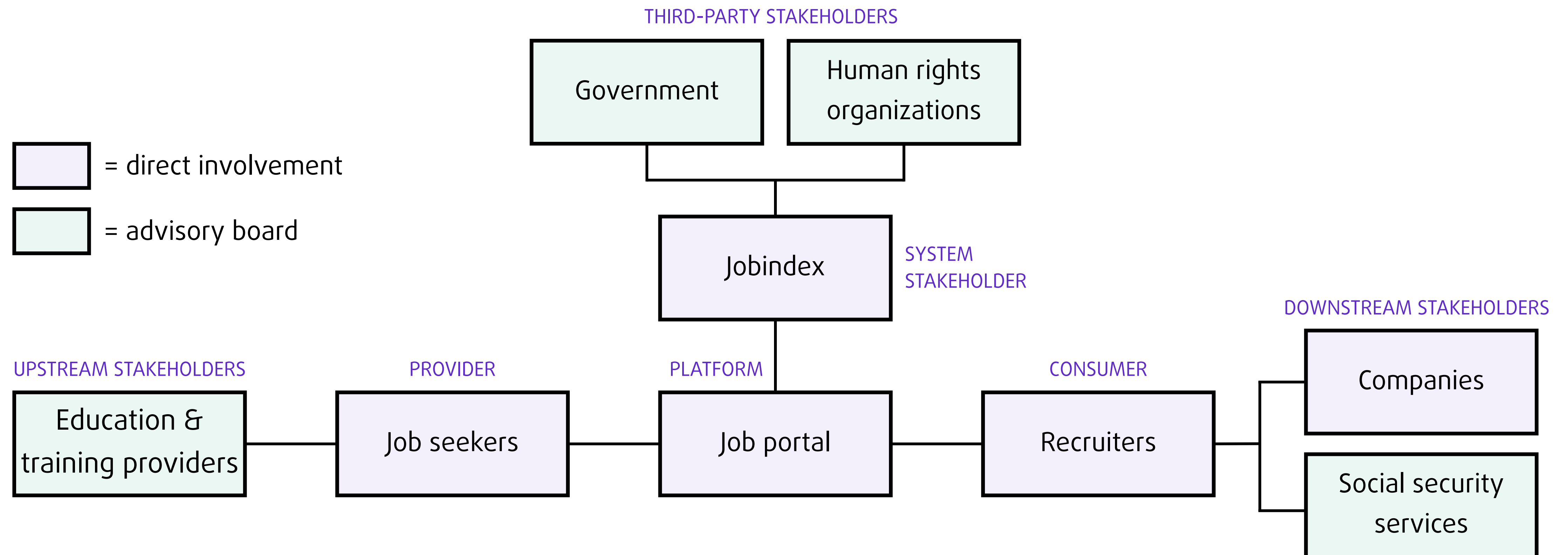
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- ▶ Integrating developed solutions into Jobindex' infrastructure

MAPPING STAKEHOLDER NEEDS TO FAIRNESS METRICS

37

- ▶ Core stakeholders will be interviewed about their needs, fairness notions, etc.
 - Others are represented in our advisory panel



► Jobindex

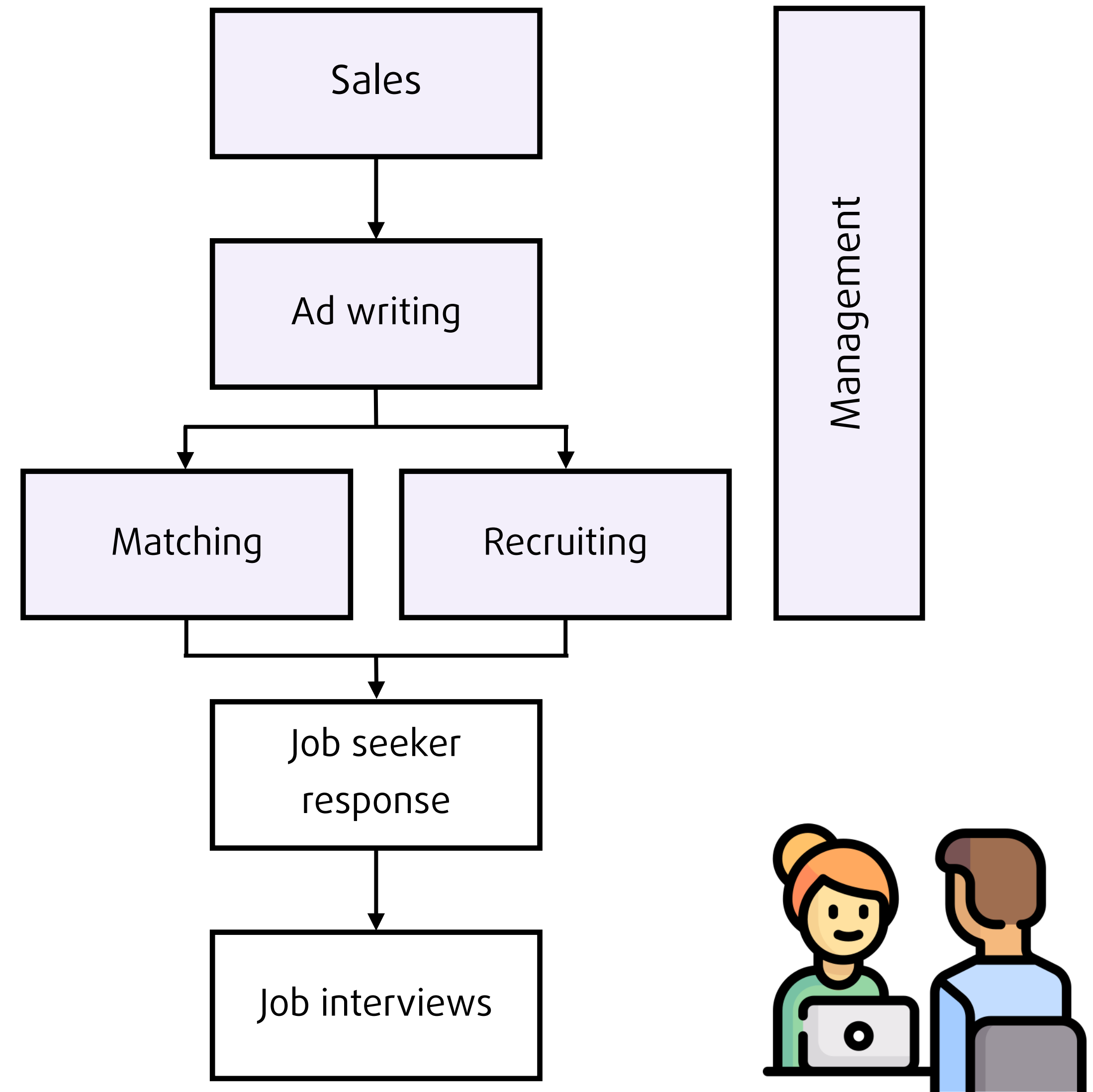
- 26 interviews completed
- Divided over different departments involved in matching process
- Includes management and regular employees

► Job seekers

- 15-20 interviews scheduled

► Companies

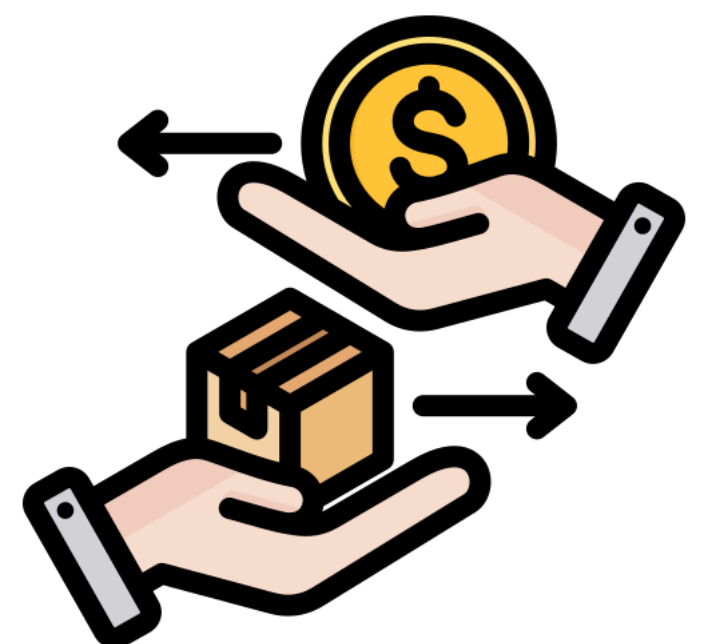
- 5-10 interviews scheduled



- ▶ Interviews are tailored to each interviewee
- ▶ Typical interview elements
 - What does fairness in algorithmic hiring mean to them?
 - Sharing our definition
 - Interviewees provide examples of unfair situations from experience
 - Getting their feedback on our example scenarios of unfairness
 - Brainstorming on how we could/should measure fairness
 - Brainstorming on how we could/should mitigate biases



- ▶ **Sales** (= are the first to discuss the job opening)
 - **Age discrimination**
 - Customers prefer **younger** or **older** candidates
 - **Gender**
 - Customers **reveal the mental model** of their ideal candidate by referring to them as “he” or “she”
 - Customers attempt to find out whether **female** candidates **already have kids** or **are planning to** (to avoid paying for **maternity leave**)
 - **Ethnicity / country of origin**
 - Explicit rejection of candidates with **specific ethnicity or country of origin**
 - Requests for candidates that speak **fluent Danish**



► Ad writing

- Core task is to write better job ads in collaboration with the customer
- Part of this involves **removing discriminative language** (e.g., gendered terms)

► Recruiters

- Can often tell from a blind resume what the likely sensitive attributes of the candidate are

Masculine-coded	Feminine-coded
Headstrong	Compassionate
Fearless	Understanding
Competitive	Nurturing
Driven	Interpersonal
Self-reliant	Kind
Dominant	Agreeable
Greedy	Affectionate

Gaucher, D., Friesen, J., & Kay, A. C. (2011). Evidence that Gendered Wording in Job Advertisements Exists and Sustains Gender Inequality. *Journal of Personality and Social Psychology*, 101(1), 109.

- **Emergent definition** of fairness from the interviews
 - For a given job, if there are N **qualified** candidates in the set of available job seekers, they should all have the **same chance of being exposed to/contacted by** the recruiters, regardless of their sensitive attributes
- ★ Points to notion of **Individual fairness**
- ★ Strong focus on **qualifications!**
- ★ “Exposed to” and “contacted by” are not the same (although the recruiters see them as the same)
- ★ They are not aware of the algorithmic biases that could be present in the recommendation/search results they are presented with
- ★ They **acknowledge they are biased** but at the same time **not question how this impacts their decision-making**



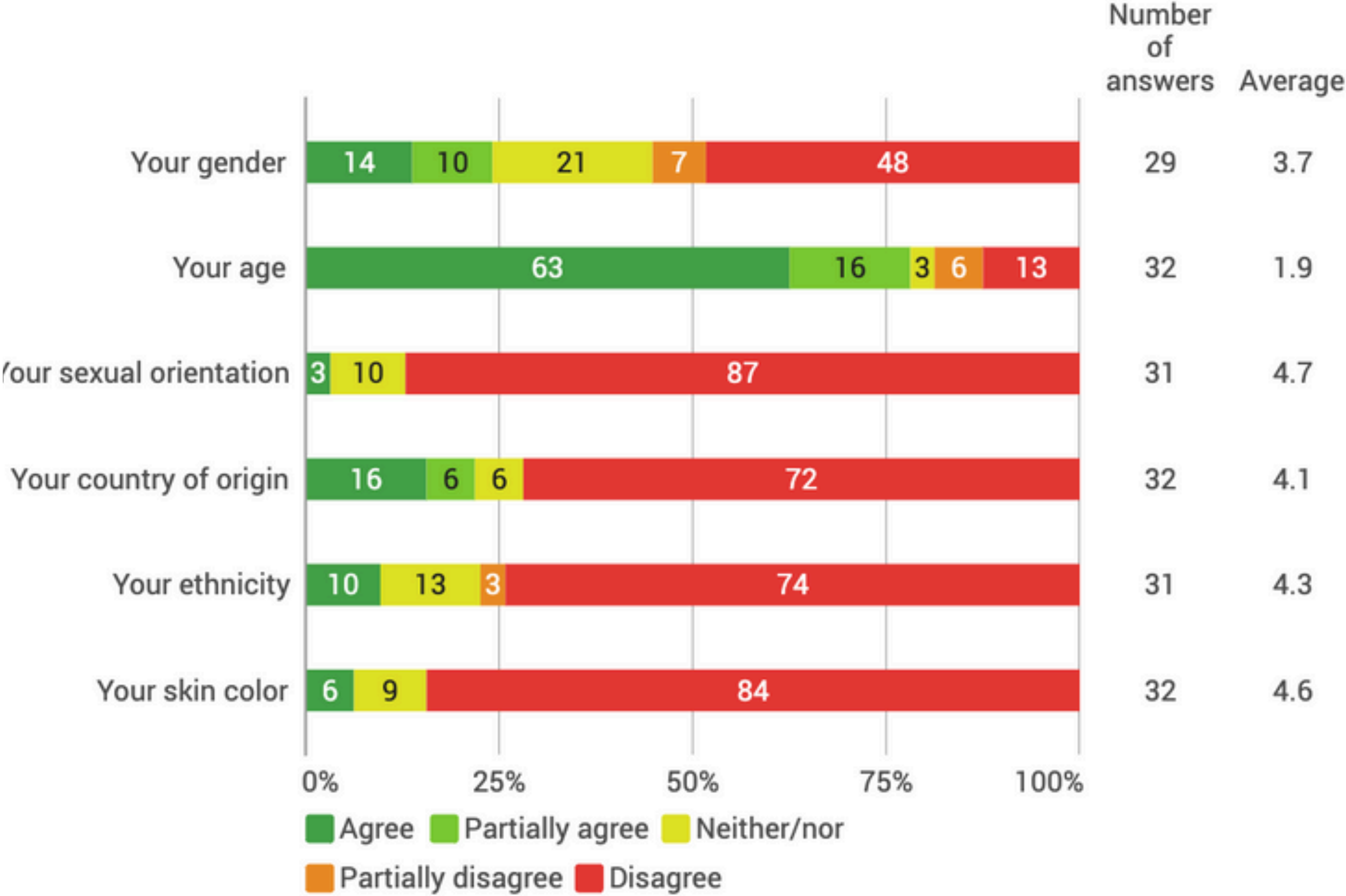
- Thoughts on **measuring** fairness
 - Compare recommendation/search results to **group proportions for a sensitive attribute**
 - ★ Whole population, resumés in the job database, specific industry, specific industry sector, similar positions
 - Consider **response rate** in this comparison
 - ★ Proportion of group A in set of contacted candidates may be different from A's share among the positive responses
 - Fairness depends on **size of the candidate pool**
 - ★ Smaller pools are harder to make fair
 - Some **divergent opinions** on fairness
 - ★ “If the set of contacted candidates are all qualified, then it is fair.”



► Next steps

- Interviews with job seekers
- Interviews with companies
- Mapping findings to fairness metrics

To what extent do you agree that you have been treated unfairly while job seeking due to the following?





QUESTIONS?