ETF Working together Learning for life

Big Data for Labour Market Intelligence

Day 1

System presentation and Outcomes

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burningglass TECHNOLOGIES

Topics

1. Goal & context
2. Challenges
    1. Stakeholders
    2. The functional architecture
    3. Data ingestion techniques
    4. Data processing pipeline
    5. Classification techniques

Topics

1. **Goal & context**
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Context

Continuously evolving Labour Market:

- Digitalization of professions
- Relevance of Soft skills
- Internationalisation
- New professions and skills emerging
- Smart and Remote working
- Impact of Covid-19 pandemic
- …

We need *something* that can help us monitor and analyze **how** LM is evolving, to support Decision Makers taking **the right decisions at the right time**

What we have / what we need

We already have **official statistics**, that are:

- *Representative*
- *Strong* in terms of value

But we can benefit of **additional, complementary information** that could be:

- *Fast*, to track what's happening now (e.g. Covid-19 Impact analysis)
- *Granular* and *adherent* to real and current market terms, to capture emerging trends analyzing what companies are actually looking for

How to find a similar, complementary source of information?
Using **Web Labour Market**

Why Web Labour Market

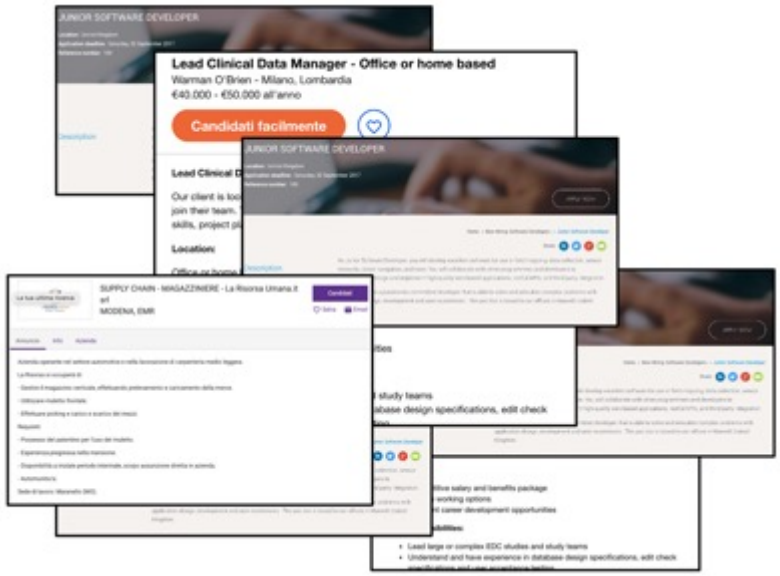
It's the exact representation of what companies are looking in a given period:

- Up to date: companies publish an announcement when they actually need to hire
- Detailed: an announcement describes as well as possibile the specific need, in terms of:
  - Profession needed
  - Requirements (skills, experience, educational level,…)
  - Working context (place, contract, sector, working hours,…)
- Adherent to reality: market terms are used, both for occupation and skills. This helps identify emerging terminology adopted by Market

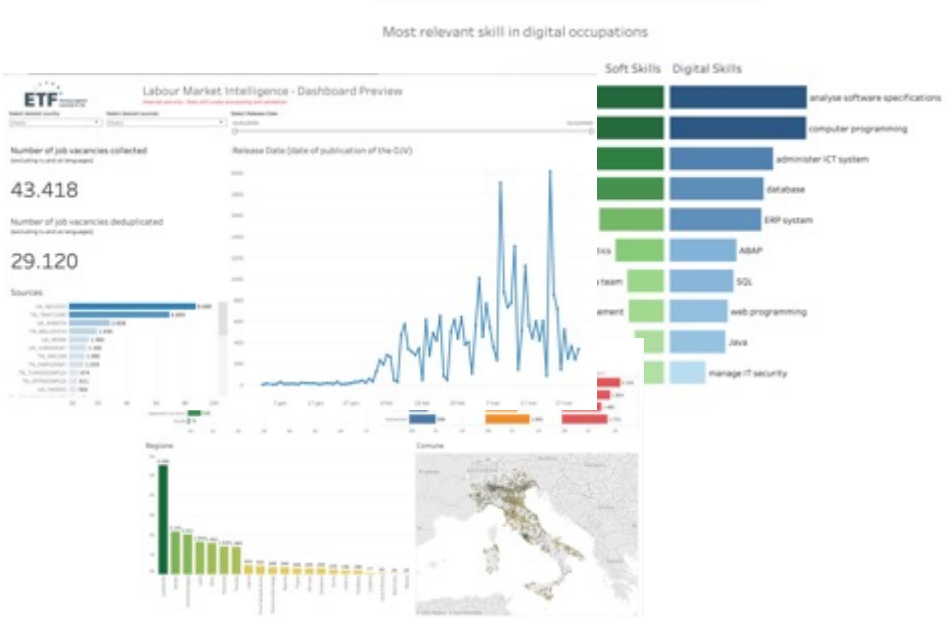
It would be great to use those information in addition to better and deeper understand how Labour Market is evolving in a given country, even compared to other countries

Our Goal

Transform Online Job Advertisments…



…in insights and analytics

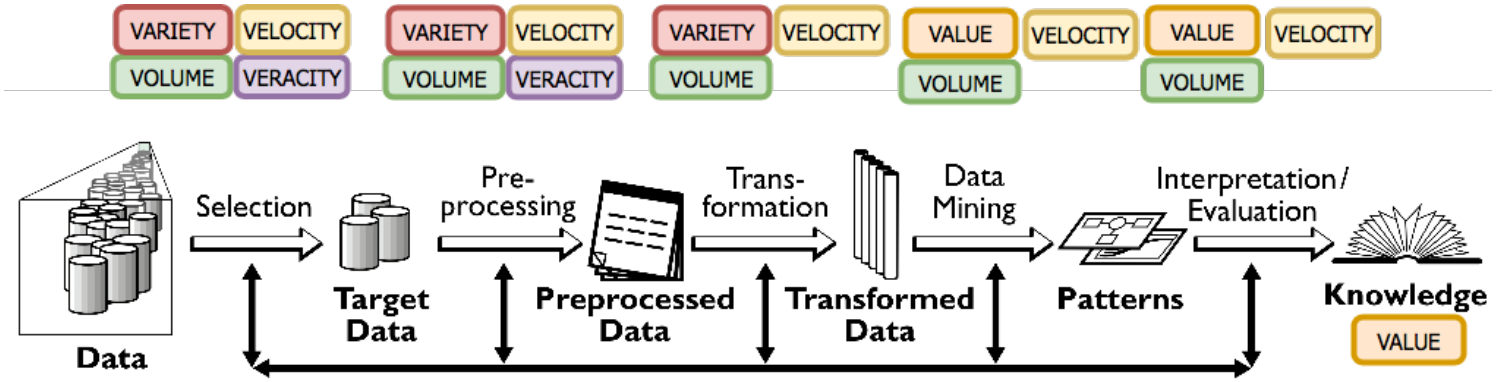


Challenges

- Handle a huge **amount** of near real time data
- Data coming from web → Need to detect and reduce **noise**
- **Multi language** environment
- Need to relate to **classification standards**
- Find a way to **summarize and present** a wide and complex scenario

Methodological background

KDD – Fayyad, 1997



VARIETY

Unstructured data (plain text to be processed)

VELOCITY

Real time data

VOLUME

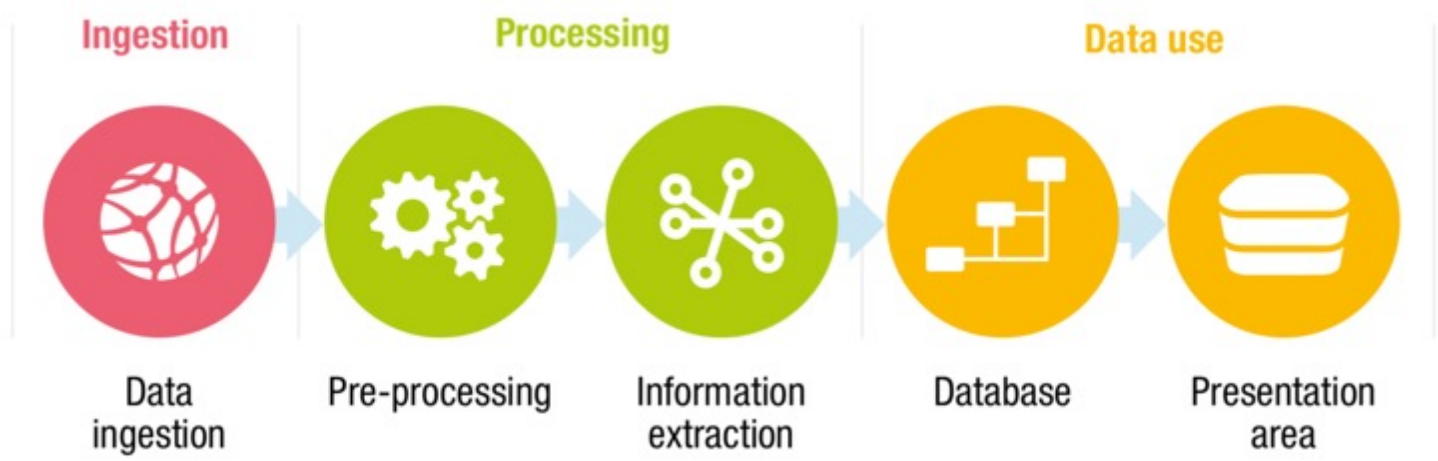
Huge amount of data (Terabytes)

VERACITY

Data is noisy, uncontrolled

Our Approach

KDD 4 LMI



Some Outcomes

- Skillspanorama – Skills in Online Vacancies
  - https://skillspanorama.cedefop.europa.eu/en/indicators/skills-online-vacancies
- Skills OVATE
  - https://www.cedefop.europa.eu/en/data-visualisations/skills-online-vacancies
- ETF – Big Data 4 LMI
  - Tunisia
  - Ukraine

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Stakeholders

Project Leader

Key Users

Domain Experts

End Users

Project leader

- ETF
  - Lead the project with the steering committee
  - Define the scope of the project
  - Define key organizations
  - Maintain relations with EU stakeholders
  - Provide advice

Key Users

- ETF, Burning Glass
  - Define requirements
  - Monitor quality of the project
  - Provide input to the development of the project
  - Manage the landscaping
  - Validate overall data flow and methodology

Domain Experts

- International Country Experts
  - Provide the knowledge and expertise
  - Execute the landscaping
  - Understand the language/terms of their context
  - Evaluate the accuracy of the results
  - Test the product
  - Provide feedback

End Users

- Decision Makers and Business Users
  - (Visual) Explore dataset, analysis and aggregate data
  - Define new analysis processes
  - Produce Data storytelling
  - Make decisions by exploring data
- Data Scientists
  - Apply new machine learning models and AI techniques
  - Extract new insights from the data
  - Apply advanced data modelling to the dataset
- Data Analysts
  - Interprets data and turns it into information
  - Identifying patterns and trends
  - Extract and analyze aggregate data
  - Publish and share their analysis

Topics

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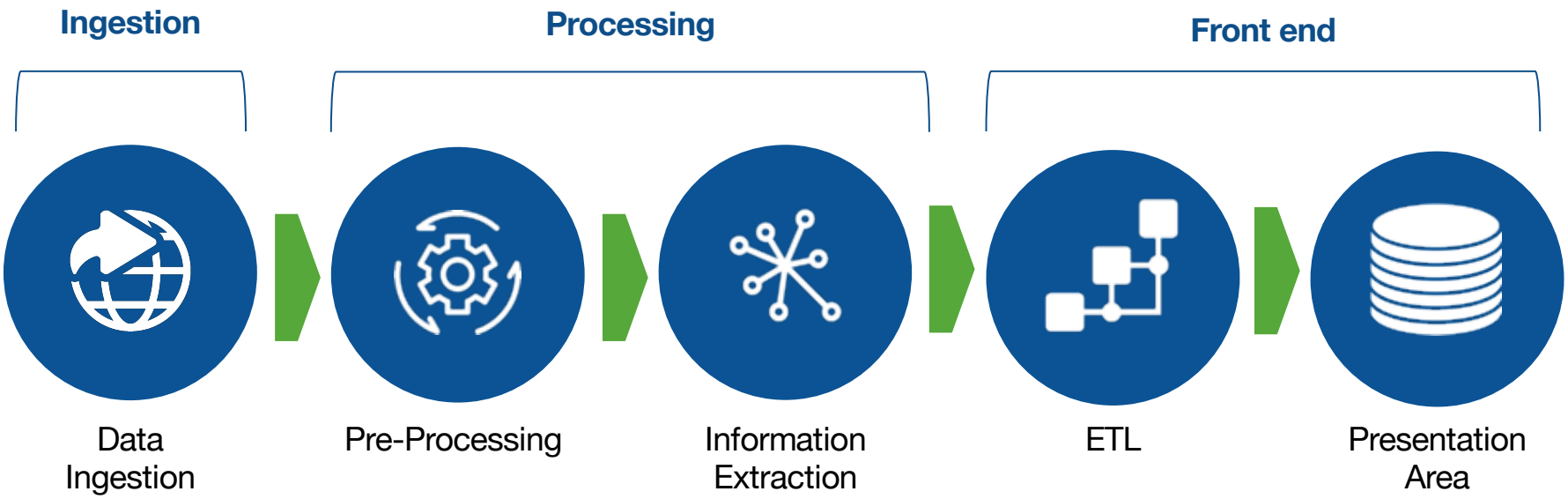
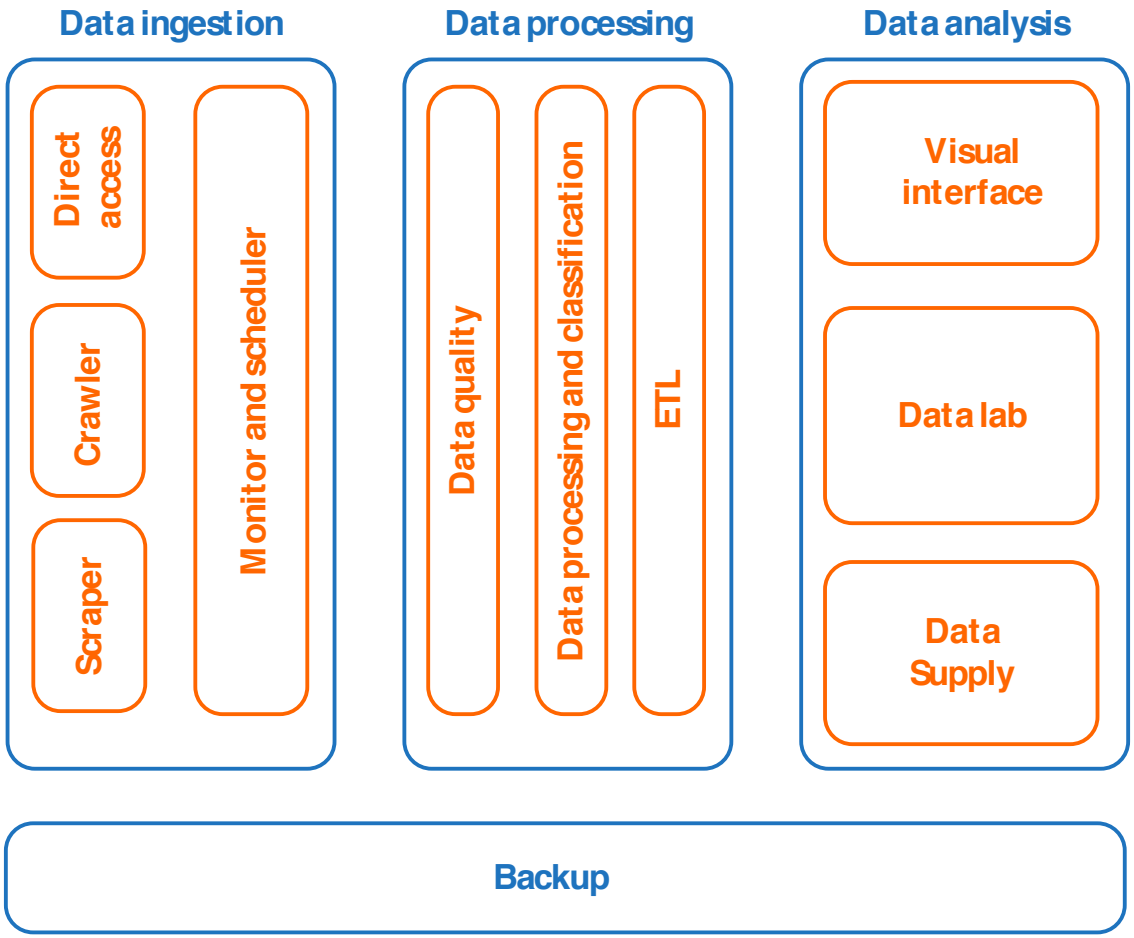
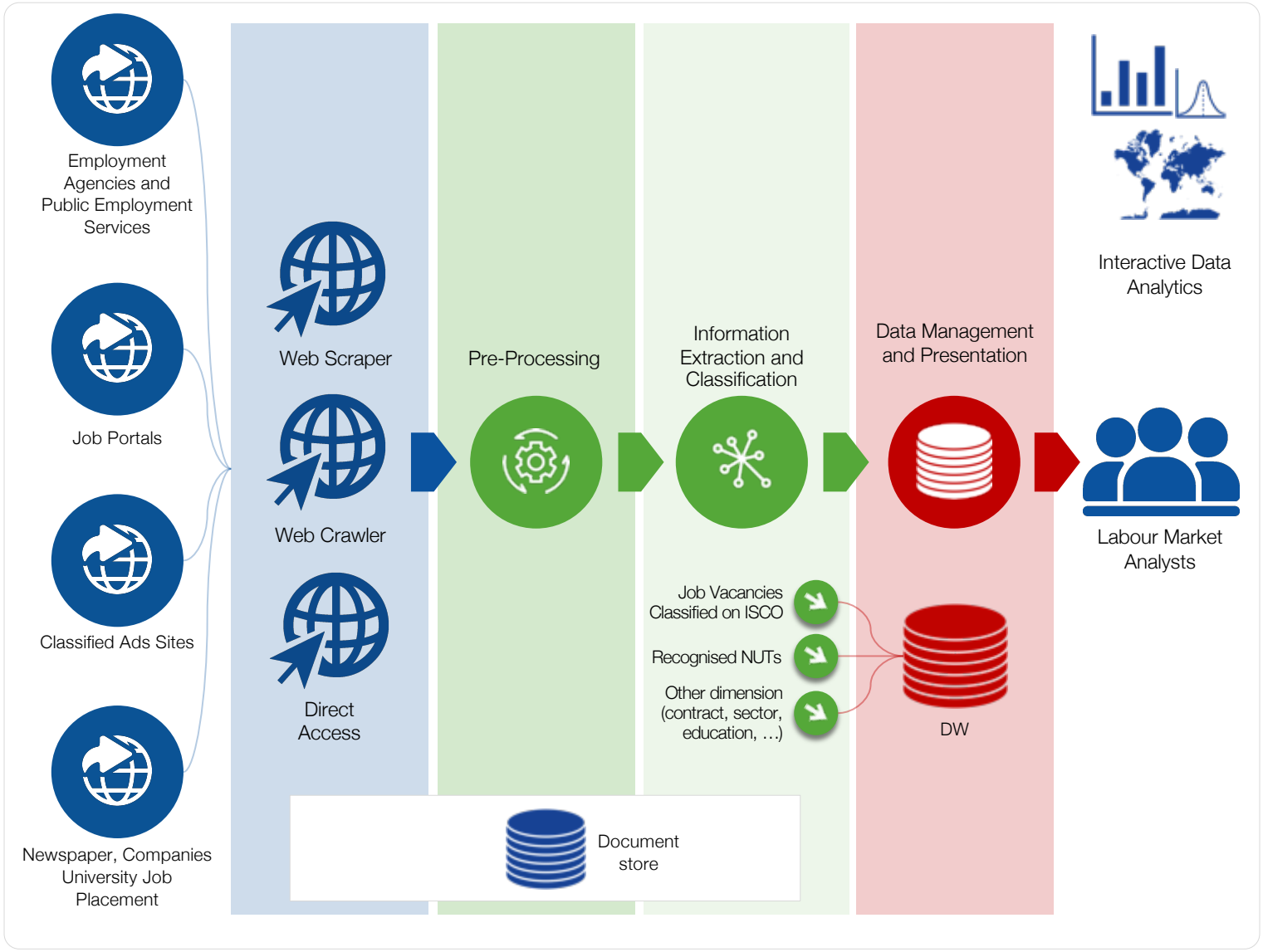
Overall Data Flow



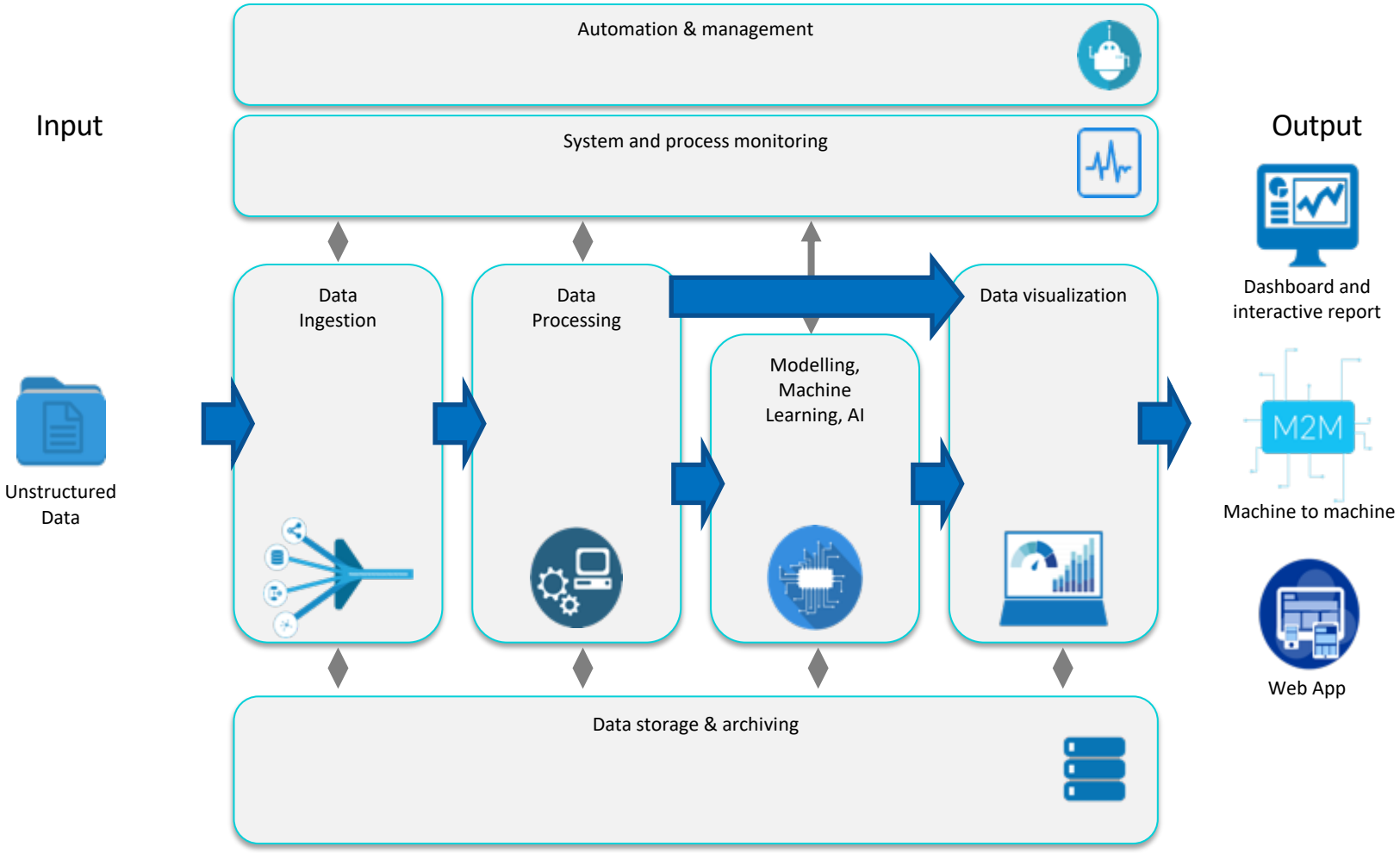
Conceptual architecture



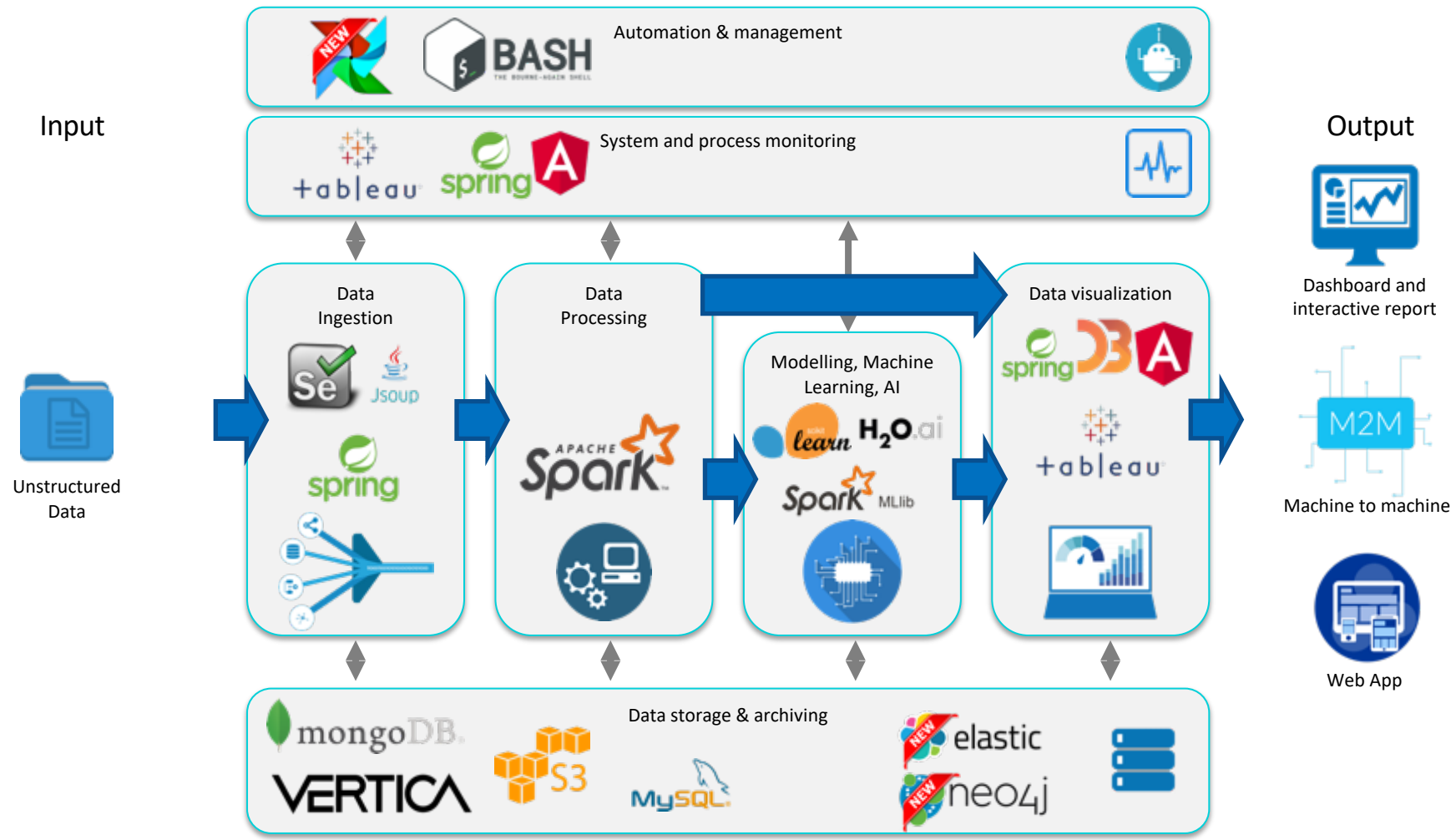
Logical view



Physical view



Technology view



Key design projects

- Micro-services
- Componentization
  - Component specialization
  - Small applications
  - Portability
  - Reuse
  - Maintenance
- Scale Out
  - Performance

Key components

- Data ingestion: collect raw data from OJV in both structured and unstructured (raw text) formats
- Data processing: classify data through machine learning techniques
- Data analysis: extract information from data and make it available through visualization
- Backup: store data in a safe environment to allow warm and cold restore

Infrastructure Challenges

- Manage multiple **parallel ingestion** activities
- Availability of **high performance** computational infrastructure **at a glance**
- **High memory** requirements
- High **storage** volumes to store source and staging data
- Big data environment
- **Scalable** architecture

Big Data Flow

Quality requirements

Micro-services design

Components by definition

Infrastructure challenges

Context

Manutability

Monitoring

Scalability

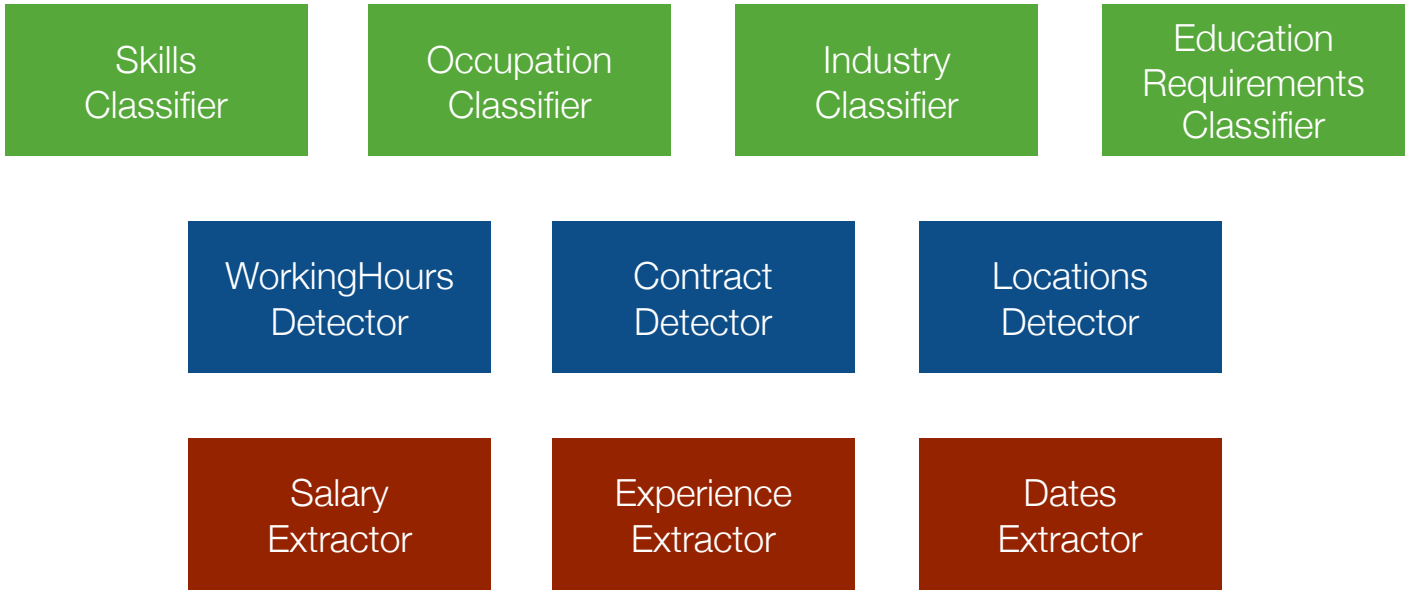
Updates

Onboarding

Pre-Processing Microservices

Language Detector	Spam Filter	No-Vacancy Filter	Stemmer
Deduplication component	N-gram component	Text Cleaner	Merge Vacancy
TF-IDF Transformer	Document2Vec	Tokenizer	StopWords Removers

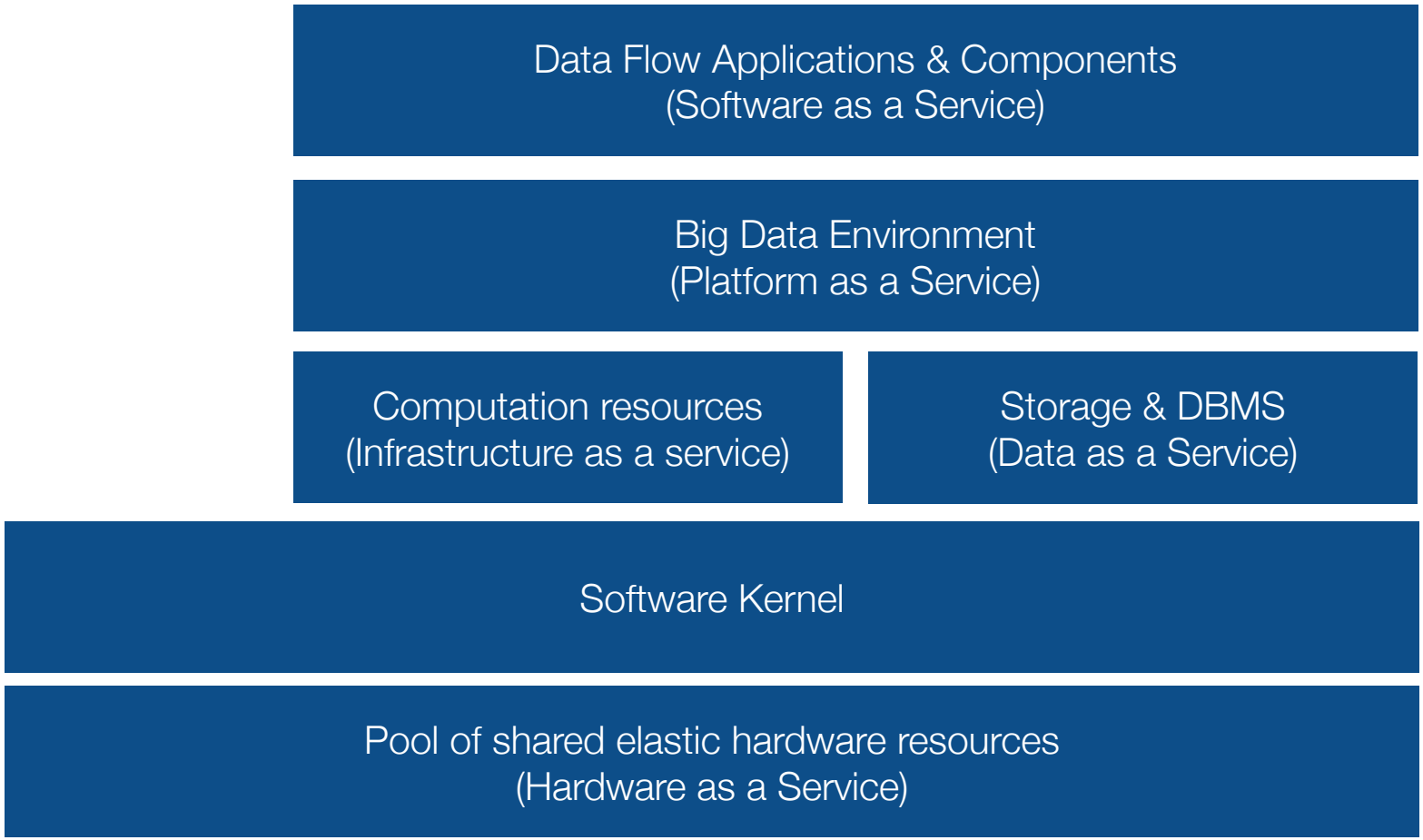
Classification Microservices



Technology requirements

1. Services on request
2. Network access
3. Resource pooling
    1. Governance
4. Quick elasticity
5. Measurement of services
    1. Data Quality
    2. Performance
6. Portability (on-premises and different cloud services)
7. Polyglot
    1. Computer programming languages
    2. Technologies

Organic view



Recap & Keywords

- Key components and data flow
  - Ingestion, Processing, Classification, Presentation
- Componetization and micro-services
- Eterogeneous and big data stack
  - Selenium, Hadoop, Spark, Sklearn, Spark
- Scalable Enviroment
  - Cloud

Questions?

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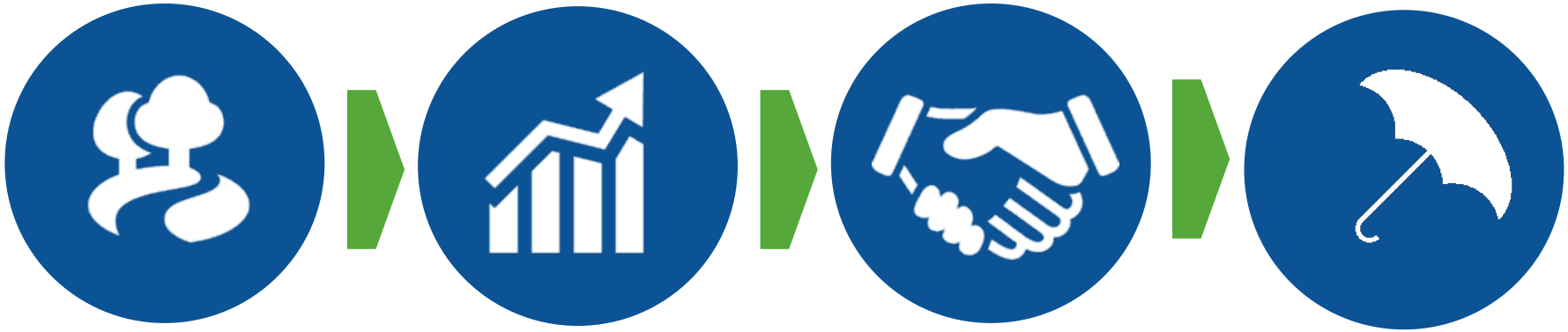
Landscaping

A **Landscaping activity** is performed to produce a list of **sources** (web portals) that are relevant for the Web Labour Market in a given country.

A Country Expert **validates** this list, that will become the initial step of the LMI System

Source selection strategy

4 Processing Steps



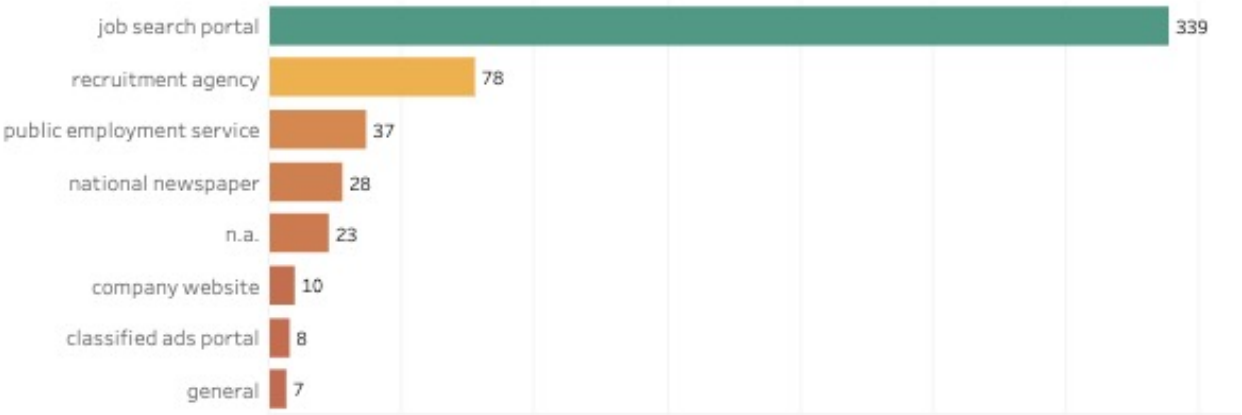
Source selection in landscaping

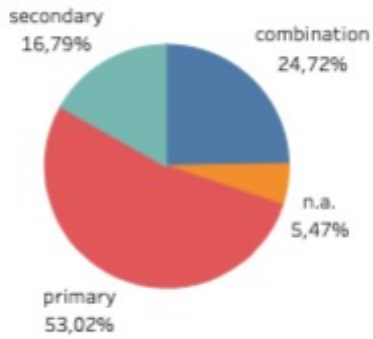
Augmentation

Agreements

Coverage

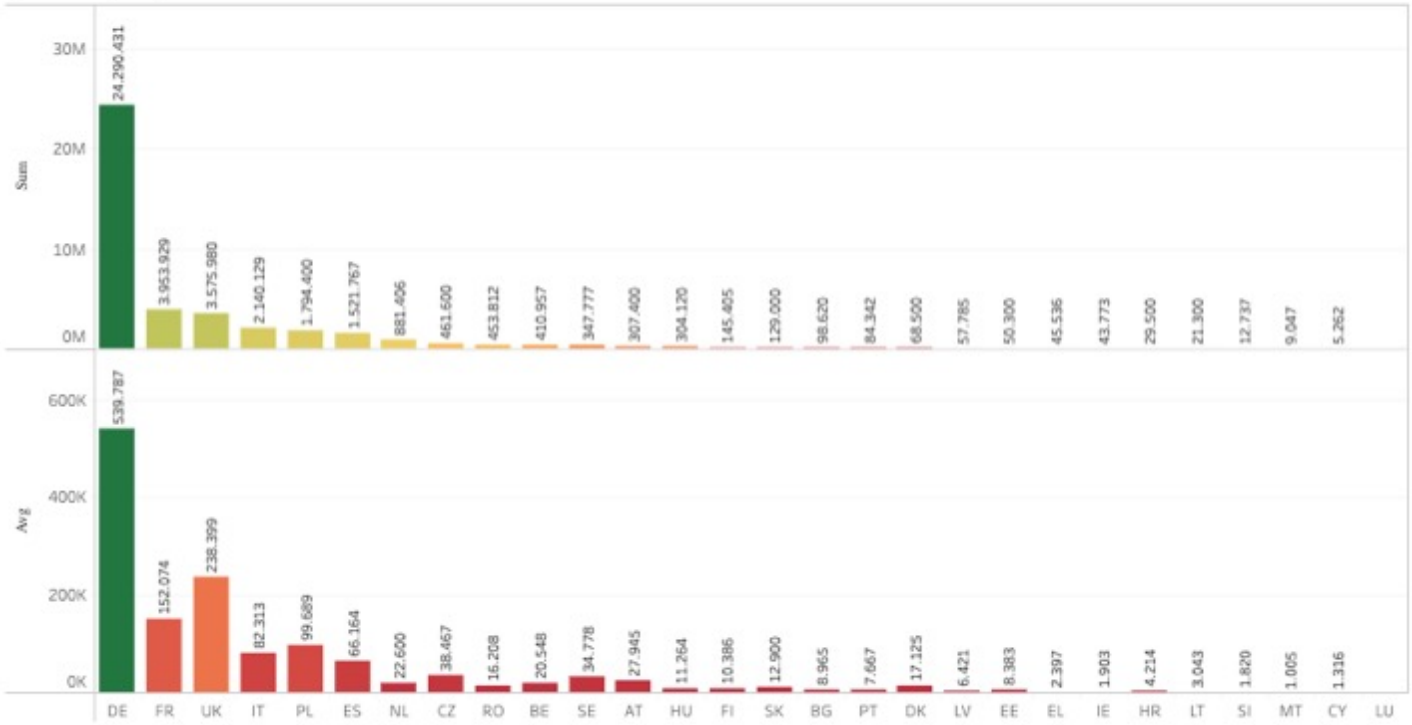
Sites by type of operator

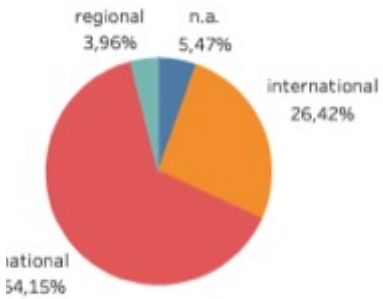


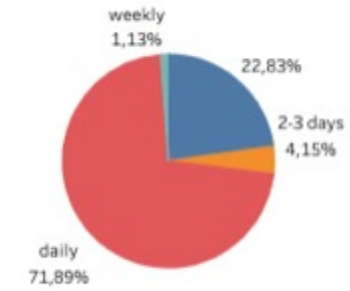


Vacancy volume by country

(estimated by ICE)







Augmentation

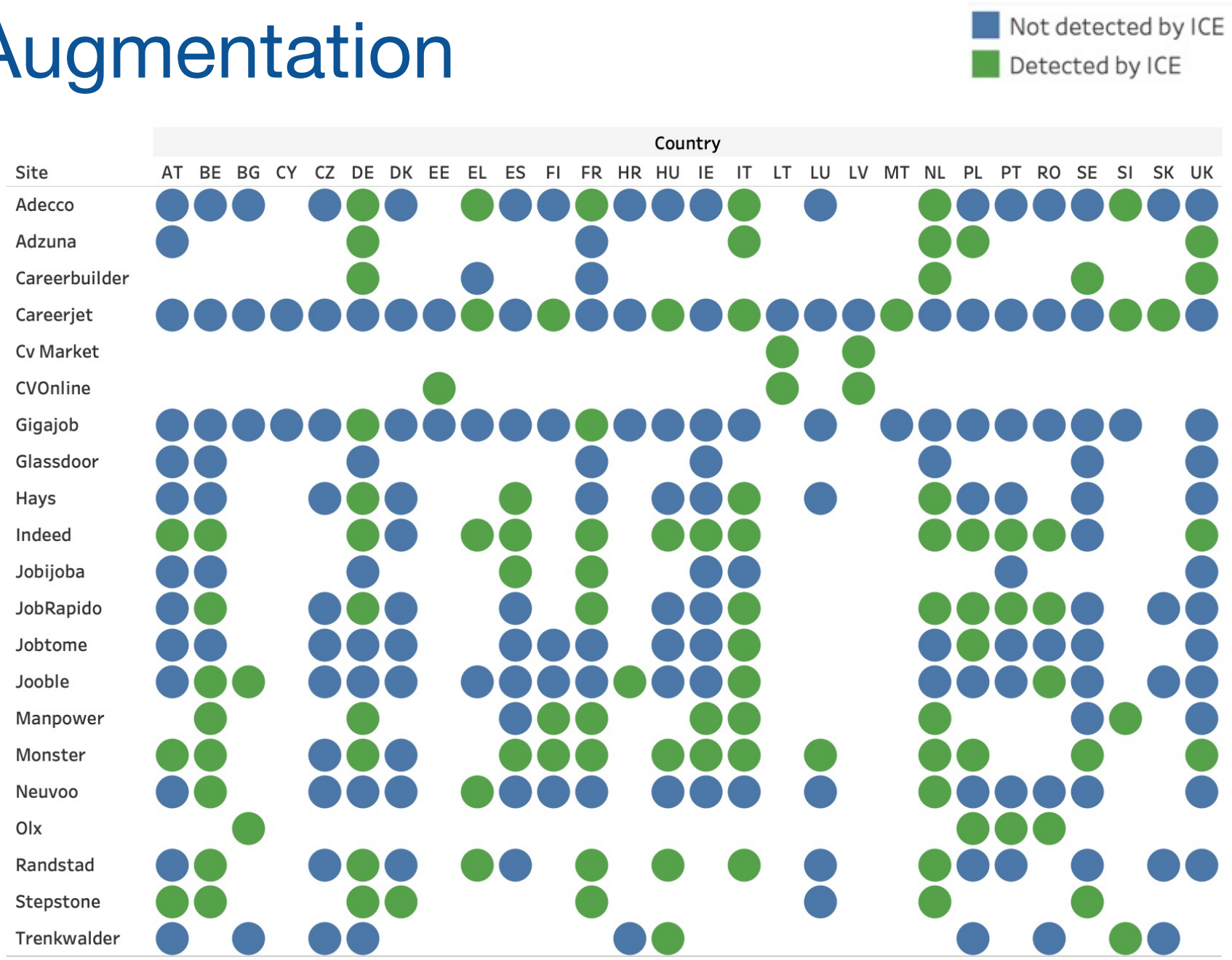
We analysed the results of the landscaping activity

- Completing the mapping of transnational sources
- Adding further transnational sources
- Adding the complete set of EURES sources

In order to define

- a priority list to define agreements
- a relevance order to realize data ingestion channels

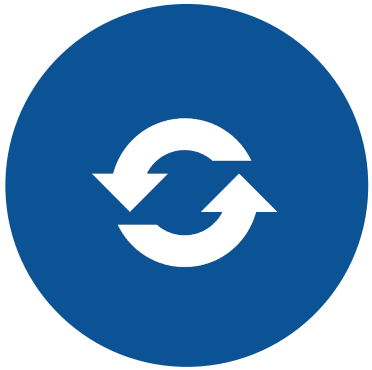
Augmentation



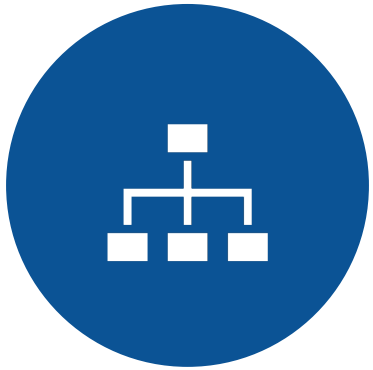
Relevance and ranking of sources

Volume

Type of
web portal



Data
Update



Structured
Data

Data Ingestion phase

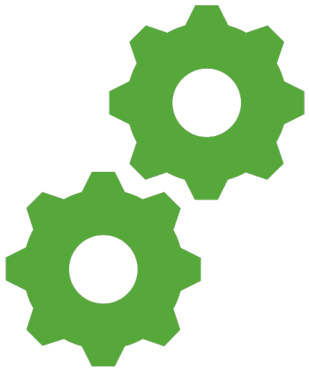
The process of obtaining and importing data from web portals and storing them in a Database

Focus on volumes

Coverage augmentation & maximization

Direct agreements with the most relevant sources

Ingestion Challenges

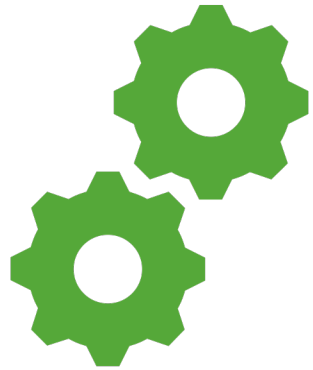


Robustness of the process

Quality of data collected

Scalability and Governance

Ingestion Challenges



1. Robustness

Issue: potential technical problems when gathering data from a source (unavailability, block, changes in data structure)

Risk: loss of data

Solution: redundancy

- Have the most important sites (by volume and/or coverage) ingested from two or more sources
- Avoid loss of data in case of troubles with a source
- Collect data from both primary and secondary sources

Ingestion Challenges

2. Quality

Issue: need to obtain data as clean as possible, detecting structured data when available

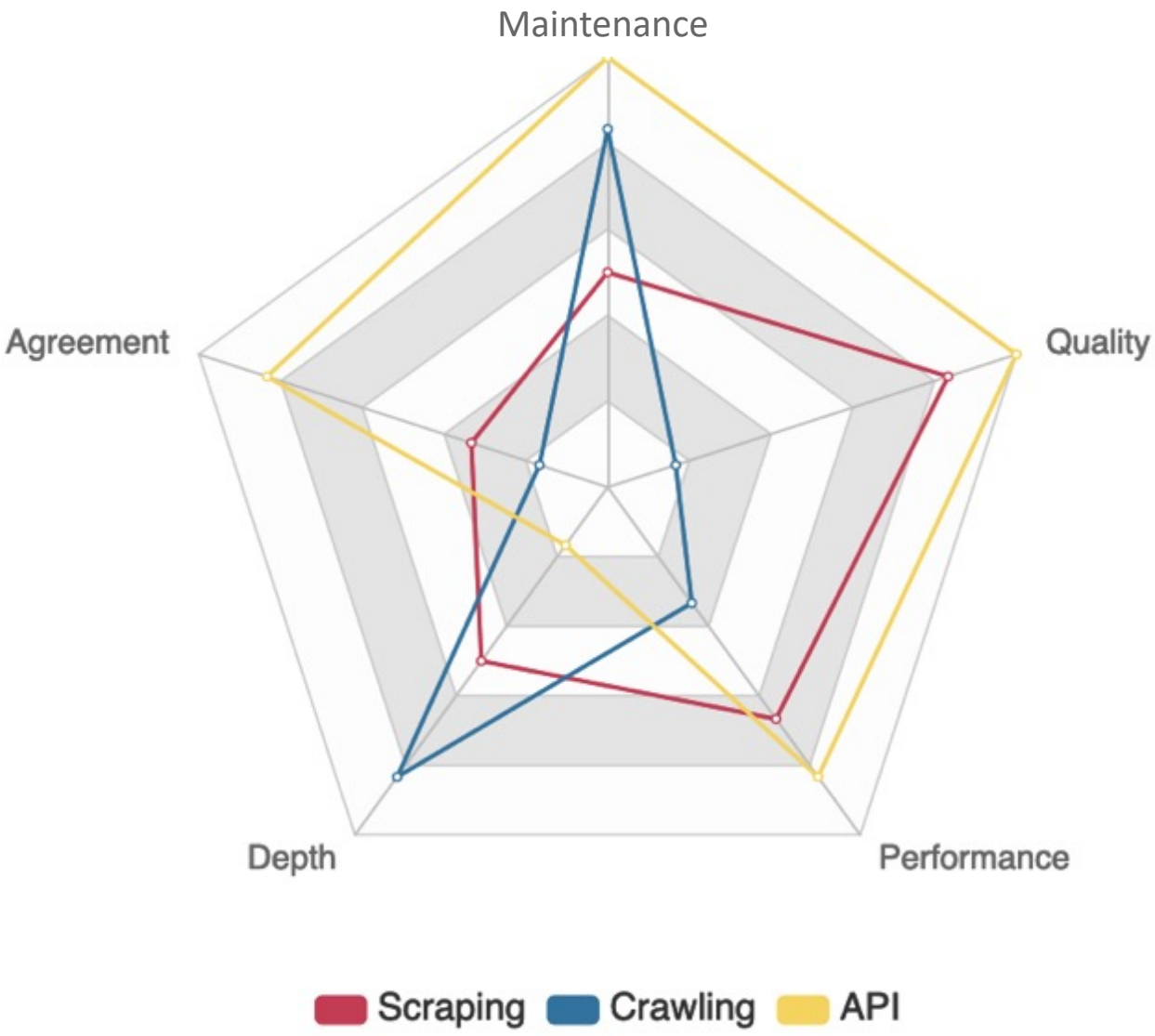
Risk: loss of quality

Solution: tailored ingestion. We collect data using a specific approach based on the single source:

- API
- Scraping
- Crawling

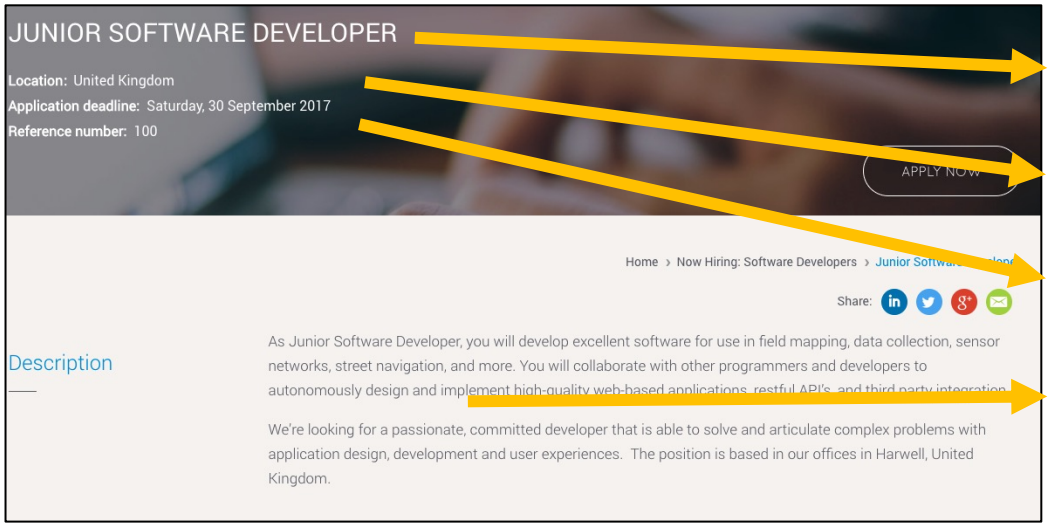
Ingestion Challenges - Quality

- API: when available (agreements), we collect mostly structured data from Web Portals.
  - Pros: Very high quality (most of fields structured)
  - Cons: Need agreement, not always available
- Scraping: if API is not feasible and the structure of the web poral is consistent, we develop a custom scraper that extract structured/unstructured data from pages
  - Pros: High Quality (many structured fields)
  - Cons: Web portal specific development
- Crawling: if web portal page structure is not consistent, we ingest data using a multi-purpose crawling approach
  - Pros: Lower quality (no structured fields)
  - Cons: Fast and Versatile approach


Maintenance
Quality
Performance
Depth
Agreement
Scraping
Crawling
API

Scraping – An example

Web scraping is data scraping used for extracting structured data from websites



Title: Junior Software Developer

Area: United Kingdom

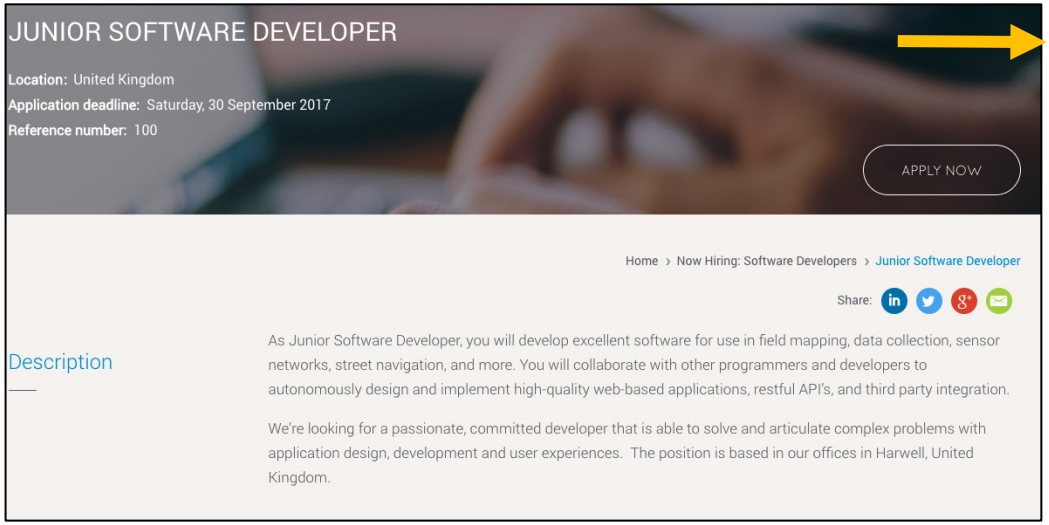
Time: Saturday, 30 September 2017

Description: As Junior Software Developer, you will develop excellent software for use …

Crawling – An example

A Web crawler is a bot that systematically browses web portals for the purpose of download all their pages.

Crawling is the most common way to get information massively from the Internet: search engine spiders (e.g. GoogleBot)



Web page:

```
<!DOCTYPE html>
  <head>
    <meta name="title" content="Junior
Software Developer" />
  </head>
  <body>
    <header>
      <h2>Junior Software Developer</h2>
      <div><div>Location</div>United
Kingdom</div>
    …
    </header>
    <div><div>Description</div>
    <span>As Junior Software Developer, you
will develop excellent software for use…
```

Ingestion Challenges

3. Scalability and Governance

Issue: need to handle a real and complex Big Data environment, simultaneously connecting to thousands of websites

Risk: Loss of Process control and loss of OJVs due to slowness of the process

Solution:

- A scalable infrastructure
- A monitoring and governance custom tool

Ingestion Challenges - Scaling

We developed a solution based on microservices, that creates and deletes “virtual browsing computers” as needed. Each computer has multiple browsers that can emulate human web navigation.

Main differences with a real computer are:

1. They don’t have a monitor, but saves pages on our Data Lake
2. We can scale up and down as needed

Recap & Keywords

- Landscaping, source selections and augmentation
- Tailored approach
  - API, Scraping, Crawling components
- Focus on quantity
  - Scaling and real-time collecting
- Real-time monitoring of the collected data

Questions?

Topics

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Data Pre-Processing – Challenges & Definitions

- Goal:
  - Feed information extraction phase with proper data
- Challenges:
  - Measure, monitor and increase Data Quality, to maximize completeness, consistency, complexity, timeliness and periodicity
- Approach:
  - Develop a multi-phase pipeline, focused on:
    - Vacancy Detection: analyze website page to select only content referred to vacancies
    - Deduplication: detect duplicated vacancy posts to obtain a single vacancy entity
    - Date detection: identify release and expire dates through vacancy description analysis
    - Vacancy duration: method to define expire date, when not explicitly available
- Features:
  - Guarantee Data Quality during all processing phases

Data Pre-Processing – Challenges & Definitions

The process of cleaning ingested data and dedupicating OJVs, to guarantee that analytical phase'll work on data at the highest quality possible

Language detection

Noise reduction

OJVs Deduplication

Pre-Processing steps

Merging

Cleaning

Text processing
and summarizing

Data Pre-Processing
The language detection

- Why:
  - Each language has different keywords, stopwords,…
  - It can reflect different cultures and Labour Market scenarios…
  - … So it's fundamental to classify the language of the OJV, so use the most proper classification pipeline
- How:
  - We trained for each language (60+) a specific classifier based on Wikipedia corpus
  - Obtained models are very accurate (~99% of precision) and fast to adopt in the pipeline
- What we obtain:
  - A fast and strong classification of the language used in each OJV
  - A way to archive OJVs for which we don't have a classification pipeline

Data Pre-Processing
How to deal with noise?

- In a Big Data environment, we must deal with noise
  - Why? Because information in gathered from the web, one of the most noisy place ever known
- First of all, we've to master which type of noise we have to face with…:
  - Web pages explicitly not related to OJVs:
    - Social network pages
    - News pages
    - Privacy policy pages
    - …
  - Web pages disguised as OJVs:
    - Training courses
    - CVs
    - Consulting services
    - …

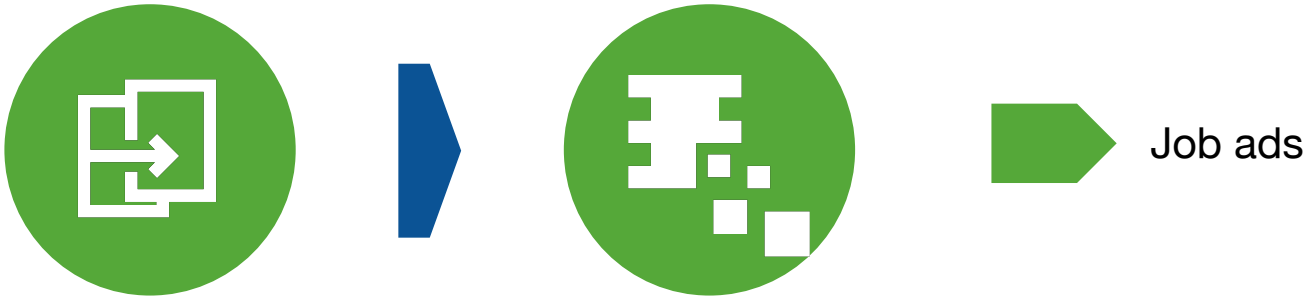
- …Then, we have to detect and handle duplicated OJVs:
  - Generally, a vacancy is posted on multiple portals
  - If we deal with them as distinct, we would overestimate Labour Demand
  - So, we've to detect duplicated OJVs and merge information coming from them in a single one

Data Pre-Processing
Noise Detection – How?

- 2 Steps approach:
  - Machine Learning approach
    - For each language, we trained a Naïve Bayes classifier with more than 20k web pages:
      - 10k of real OJVs related pages
      - 10k of web pages not related to OJVs
    - Accuracy of ~99%
    - Fast to train and use
    - An approach similar to a “Email Spam Detection” system
  - Fuzzy matching approach
    - Used to detect “OVJs like” webpages, but related to training offers, consulting services,….
    - It works looking ad page header and body to detect keywords (language dependent) that can help us label it like a “not-related to OJVs” page

But, before starting OJVs deduplication phase, we need to clean text to simplify and consolidate it…

Data Pre-Processing
Deduplication phase



Physical deduplication or fuzzy matching

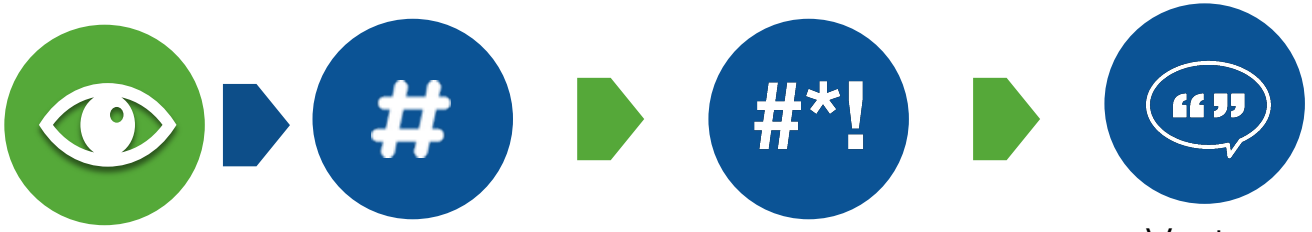
Made on the description (or content) part of the job vacancy.

Metadata matching

Using metadata coming from job portals to remove job vacancies duplicates on the aggregators websites (e.g. reference id, page url)

Text processing and summarizing

The text processing and summarizing phase aims at reducing the text to improve the process of classifications of job vacancies according to the European standards.



JUNIOR SOFTWARE DEVELOPER

Location: United Kingdom
Application deadline: Saturday, 30 September 2017
Reference number: 100

Description

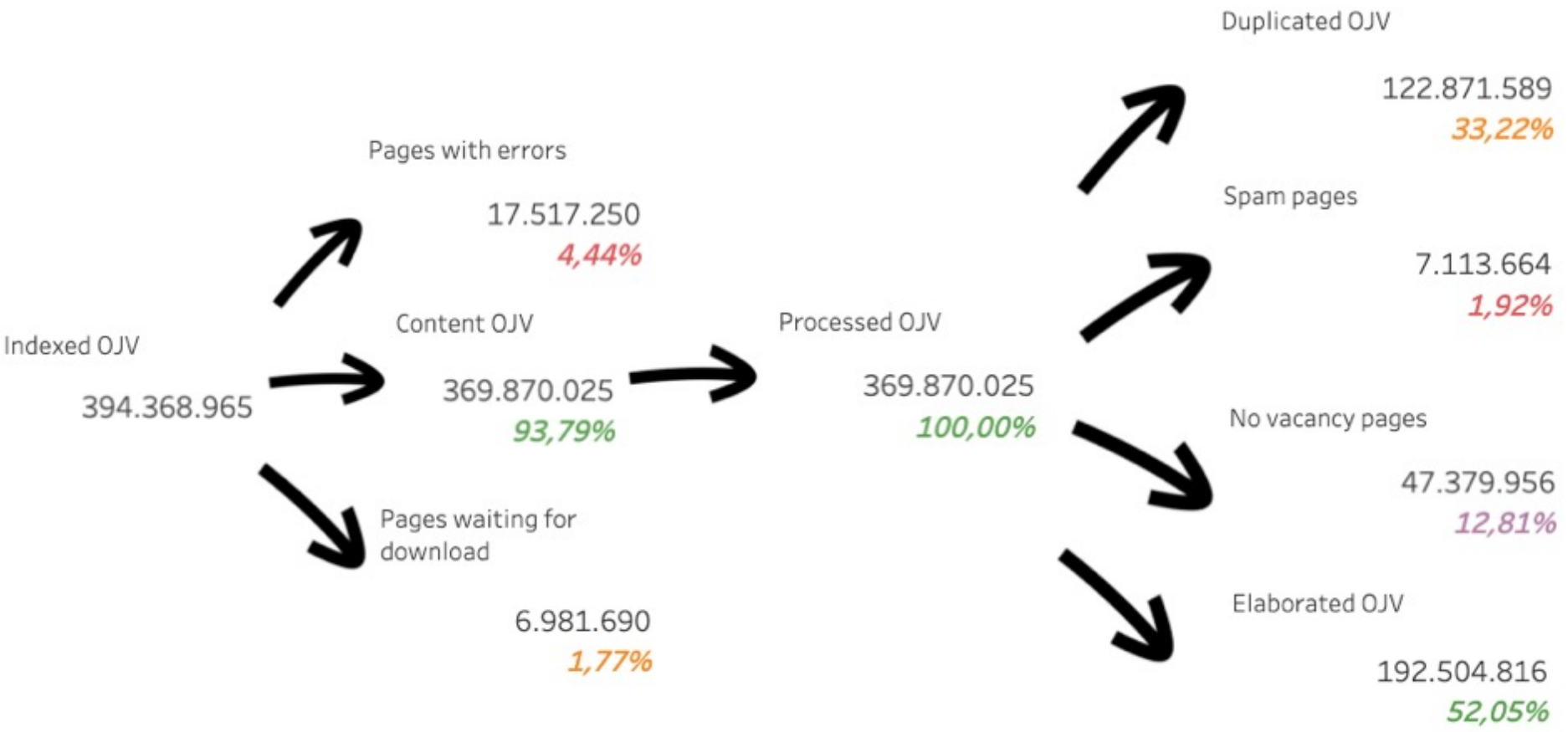
As Junior Software Developer, you will develop excellent software for use in field mapping, data collection, sensor networks, street navigation, and more. You will collaborate with other programmers and developers to autonomously design and implement high-quality web-based applications, restful API's, and third party integration.

We're looking for a passionate, committed developer that is able to solve and articulate complex problems with application design, development and user experiences. The position is based in our offices in Harwell, United Kingdom.

As Junior ⟨Software Developer⟩, you will develop excellent ⟨software⟩ for use in ⟨field mapping⟩, ⟨data collection⟩, ⟨sensor networks⟩, ⟨**street navigation**⟩, and more. You will ⟨collaborate⟩ with other ⟨programmers⟩ and ⟨developers⟩ to ⟨autonomously⟩ design and implement high-quality ⟨web-based applications⟩, restful ⟨API⟩'s, and third party ⟨integration⟩.

We're looking for a passionate, committed ⟨developer⟩ that is able to ⟨solve⟩ and articulate ⟨complex problems⟩ with ⟨application design⟩, ⟨development⟩ and ⟨user experiences⟩.
The position is based in our offices in ⟨Harwell⟩, ⟨United Kingdom⟩.

Data Pre-Processing – Results
The noise

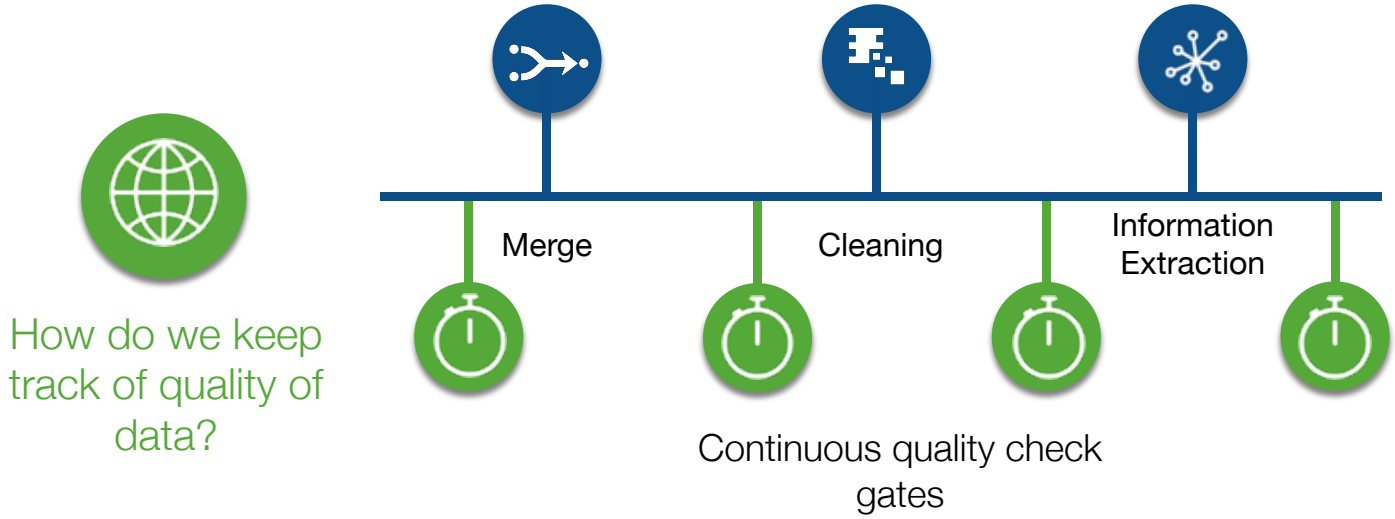


Data Pre-Processing
What to do with noise?

We don't physically delete noise

We collect it to keep track of the overall process, and monitor:

- Noise type → To identify need to develop some deeper quality check process
- Noise trends → To detect sources that are increasing/decreasing noise and deal it
- Analytical purposes → Analyse country-specific cultural environments, like the use of OJVs portal to promote training courses
- Monitoring → Keep track of the overall process



Recap & Keywords

- Focus on quality
  - How remove noise?
  - Deduplication activities
- Languages challenge
  - Tailored component for each language
- Track of quality of data
  - Continous quality check and gates

Questions?

Topics

1. Goal & context
2. Challenges
    1. Stakeholders
    2. The functional architecture
    3. Data ingestion techniques
    4. Data processing pipeline
    5. **Classification techniques**

Content

379.794.151

Processed

379.794.151

Elaborated

199.008.930

Contract
Structured fields collected
(% over total elaborated OJV)

23,75%

Total fields extracted
(% over total elaborated OJV)

49,00%

Method

Educational level
Structured fields collected
(% over total elaborated OJV)

5,45%

Total fields extracted
(% over total elaborated OJV)

77,63%

Method

Experience
Structured fields collected
(% over total elaborated OJV)

3,86%

Total fields extracted
(% over total elaborated OJV)

35,49%

Method

Occupation
Structured fields collected
(% over total elaborated OJV)

5,21%

Total fields extracted
(% over total elaborated OJV)

76,09%

Method

Industry
Structured fields collected
(% over total elaborated OJV)

25,36%

Total fields extracted
(% over total elaborated OJV)

78,37%

Method

Salary
Structured fields collected
(% over total elaborated OJV)

13,71%

Total fields extracted
(% over total elaborated OJV)

18,24%

Method

Skill
Structured fields collected
(% over total elaborated OJV)

49,94%

Total fields extracted
(% over total elaborated OJV)

62,52%

Method

Working hours
Structured fields collected
(% over total elaborated OJV)

18,21%

Total fields extracted
(% over total elaborated OJV)

43,11%

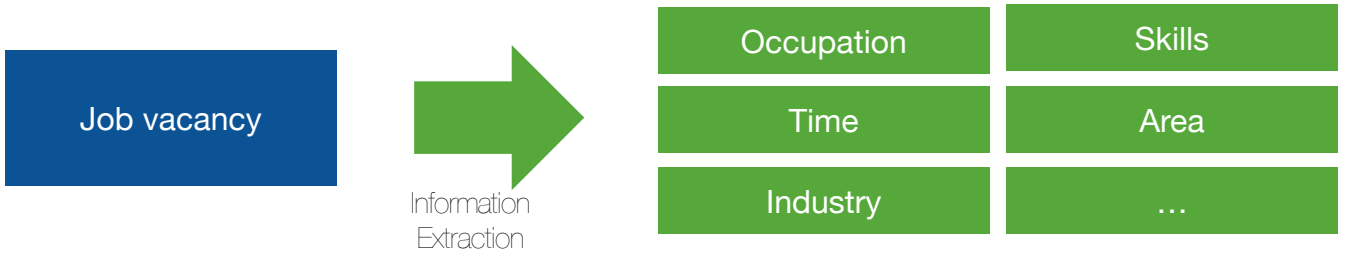
Method

Feature extraction (Equal)
Feature extraction (Similarity)

Data Classification

- Goal:
  - Extract and structure information from data, to be provided to the presentation layer
- Challenges:
  - Handle massive amount of heterogeneous data written in different languages
- Approach:
  - Develop an adaptable framework, language dependent, tailored on different information features. Some relevant challenges:
    - **Occupation** feature classification: combined methods such as Machine Learning, Topic Modeling and Unsupervised Learning
    - **Skill** feature classification: another different combined methods, such as Text Analysis with corpus based or Knowledge based similarity
- Features:
  - Guarantee Explainable information extraction, logging classification methods and relevant features.

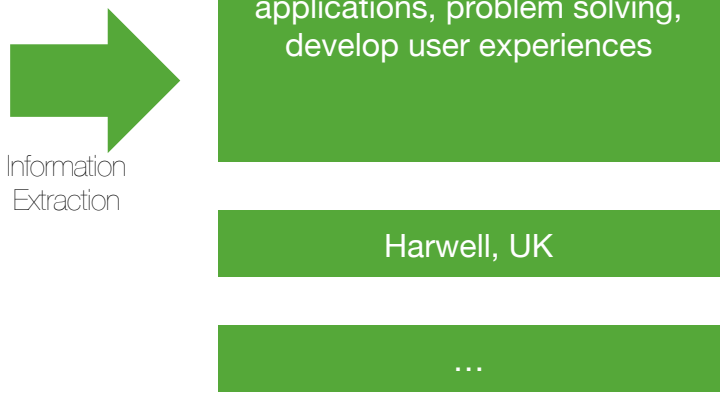
Data Classification - An example



Junior Software Developer

As Junior Software Developer, you will develop excellent software for use in field mapping, data collection, sensor networks, street navigation, and more. You will collaborate with other programmers and developers to autonomously design and implement high-quality web-based applications, restful API's, and third party integration.

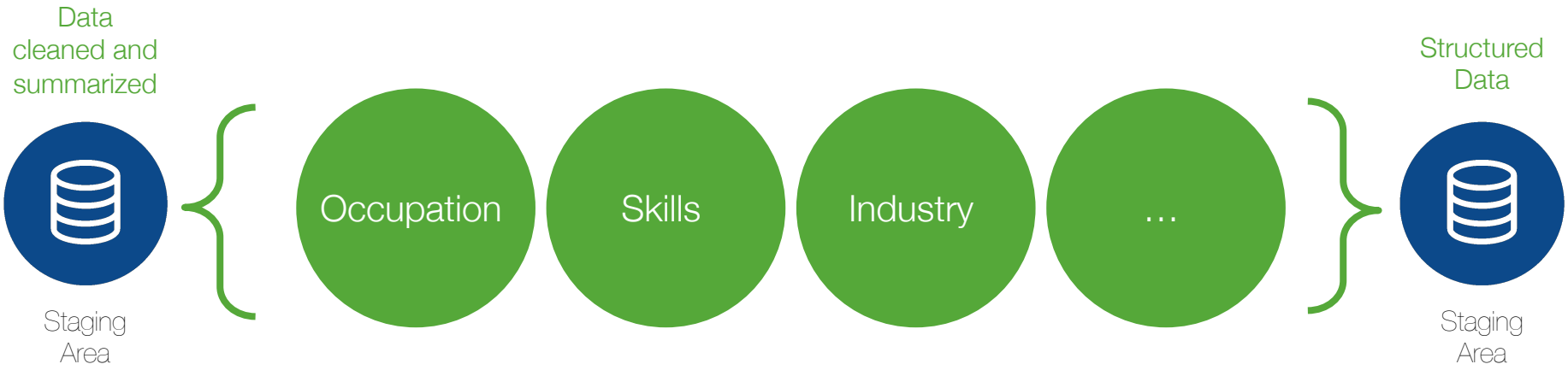
We're looking for a passionate, committed developer that is able to solve and articulate complex problems with application design, development and user experiences. The position is based in our offices in Harwell, United Kingdom.



Information Extraction and Classification
Real Time Labour Market Intelligence

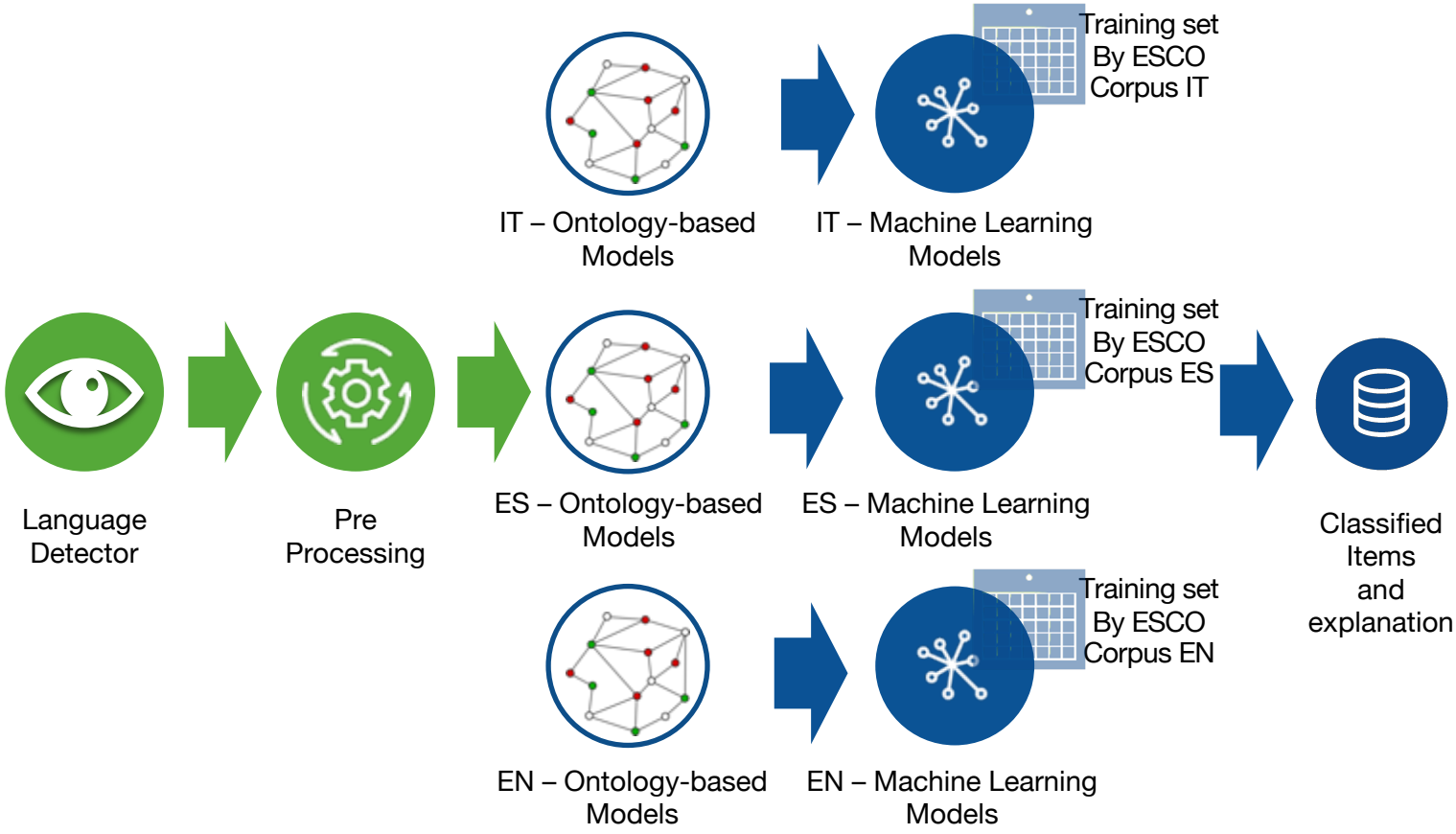
Information Extraction is an area of natural language processing that deals with finding factual information in free text.

This task uses machine learning techniques (ontology based learning, supervised learning and unsupervised learning) to match job ads with standard classifications.



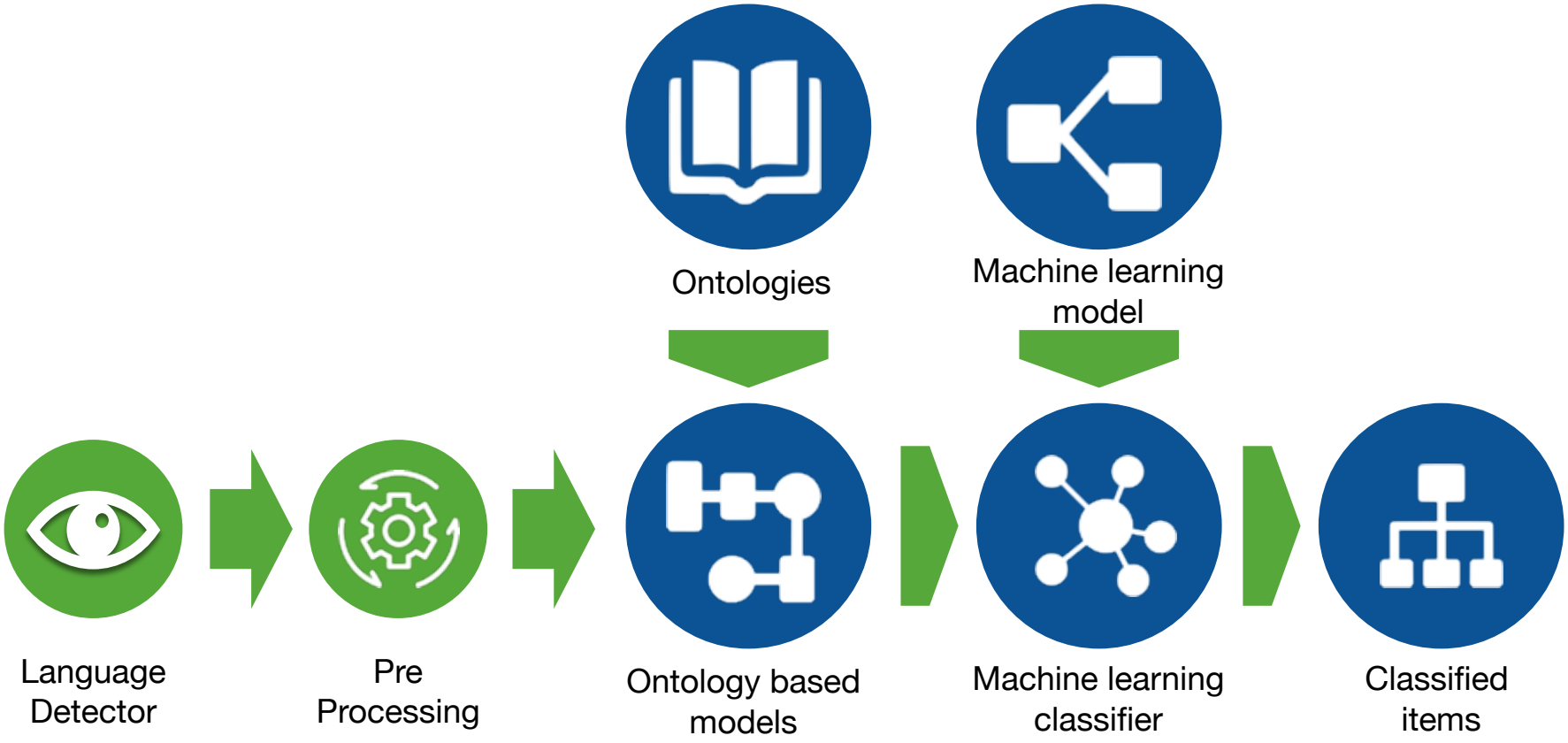
Machine Learning → Ontology based learning, supervised learning and unsupervised learning, etc.

Classification



What does “Ontology-based Models” means?
How we can use ontologies to classify?

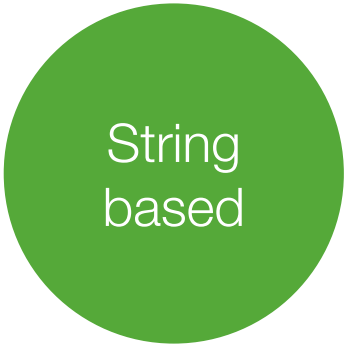
Occupations pipeline



Considerations on Occupation Classifier

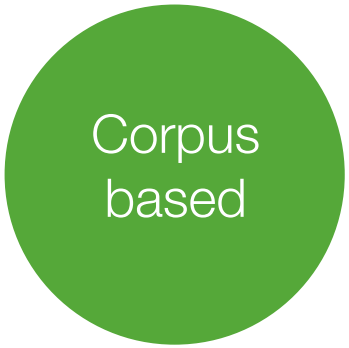
- Ontology based learning + Supervised learning
  - Esco Ontology
  - New labels from Topic modelling
- One model for each language
- Data labelled by expert from each country
  - ~100k job ads (cleaned train set using our ontology)
  - 436 possible targets
- Evaluating set 20% of gold dataset job ads
  - Weighted Precision ~86%
  - ~430 detected professions

Text Similarity Approaches



String similarity measures operate on string sequences and character composition.

Jaro-Winkler, Jaccard, Cosine similarity



Corpus-Based similarity is a semantic similarity measure that determines the similarity between words according to information gained from large corpora.

Latent Semantic Analysis, Explicit Semantic Analysis, DIStributionally similar words using CO-occurrences

Knowledge-Based Similarity is based on identifying the degree of similarity between words using information derived from semantic networks

Precision of occupation (overall)

86,66%

Validation Set (overall)

317.864

Validation Set by language

bg	ca	cs	da	de	el	en	es	et	eu	fi	fr	gl	hr	hu	it	lt	lv	nl	pl	pt	ro	sk	sl	sv
5.050	14.210	31.290	6.022	17.420	7.173	35.019	21.680	8.414	196	11.972	39.146	811	4.637	13.813	17.228	7.447	4.443	8.687	10.554	14.678	10.226	3.089	4.576	20.083

Precision of occupation by language

bg	ca	cs	da	de	el	en	es	et	eu	fi	fr	gl	hr	hu	it	lt	lv	nl	pl	pt	ro	sk	sl	sv
85,96%	86,45%	88,96%	96,89%	83,17%	85,02%	82,83%	87,39%	83,63%	68,59%	98,80%	83,89%	83,07%	89,45%	97,40%	81,30%	92,86%	96,95%	93,31%	80,02%	83,01%	95,12%	98,50%	87,78%	78,43%

Precision of occupation (lv1)

Clerical support workers	85,77%
Craft and related trades ..	86,10%
Elementary occupations	86,19%
Managers	86,32%
Plant and machine operat..	86,29%
Professionals	86,61%
Service and sales workers	89,38%
Skilled agricultural, fores..	88,79%
Technicians and associate..	85,54%

Precision of occupation (lv2)

Administrative and comm..	85,06%
Agricultural, forestry and ..	80,82%
Assemblers	84,87%
Building and related trad..	92,30%
Business and administrati..	85,66%
Business and administrati..	80,06%
Chief executives, senior o..	91,36%
Cleaners and helpers	85,11%
Customer services clerks	82,21%
Drivers and mobile plant ..	86,49%
Electrical and electronic t..	74,60%
Food preparation assista..	89,08%
Food processing, wood w..	82,61%
General and keyboard cler..	97,20%
Handicraft and printing w..	89,65%

Precision of occupation (lv3)

Administration professio..	86,21%
Administrative and specia..	84,92%
Agricultural, forestry and ..	80,82%
Animal producers	83,13%
Architects, planners, surv..	87,56%
Artistic, cultural and culin..	91,74%
Assemblers	84,87%
Authors, journalists and li..	90,72%
Blacksmiths, toolmakers ..	86,70%
Building and housekeepin..	90,33%
Building finishers and rel..	95,47%
Building frame and relate..	90,00%
Business services agents	89,57%
Business services and ad..	79,10%
Car, van and motorcycle d..	90,40%

Precision of occupation (lv4)

Accountants	83,60%
Accounting and bookkeepi..	58,14%
Accounting associate prof..	85,65%
Actors	93,41%
Administrative and execu..	84,32%
Advertising and marketin..	65,30%
Advertising and public rel..	71,63%
Aged care services manag..	78,81%
Agricultural and forestry ..	94,55%
Agricultural and industria..	76,49%
Agricultural technicians	81,32%
Air conditioning and refri..	85,95%
Air traffic controllers	84,43%
Air traffic safety electroni..	95,52%
Aircraft engine mechanics..	79,61%

Recap & Keywords

- Focus on summarization
  - How summarize data and improve our data analysts results?
- Link to standard taxonomies
  - Compare OJVs data with other sources
- Gold-set challenges (cardinality, quality and diversity)
- Mixed approaches
  - Machine learning
  - Ontology based learning
  - Text similarity and Information extraction techniques
- Model Life-Cycle

Questions?