Towards Standardization of Ontologies in Research and Industry

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AFIN 2022

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Agenda

- **Background**
- **Challenges from research and industry – problem statement**
- **Standards and ontology considerations**
- **Vision**
- **Current approach and next steps**
- **Conclusion**

Resume of the presenter

Frank-Walter Jaekel

Frank-Walter Jaekel studied vehicle design in Hamburg and computer science at the Technical University of Berlin. He is Senior scientist for interoperability at Fraunhofer IPK responsible for projects in research and industry as well as for the enterprise modelling system MO²GO (www.moogo.de). Project Manager and work package leader in European research projects such as MISSION, INTEROP-NoE, FACIT-SME, FITMAN, FLEXINET. Projects carried out in industry on the topics of software development, enterprise design, enterprise modelling and interoperability, in particular the enterprise model-based analysis, design and implementation of enterprise applications and digitalization.

Frank-Walter Jaekel is involved in the INTEROP-VLAB and DFI-e.v. activities (www.interop-vlab.eu) and member in ISO/TC 184/SC 5. Papers are published in national and international journals and conferences regarding enterprise modelling, distributed simulation, process performance indicators, risk management, enterprise interoperability, manufacturing execution systems and the modular, validation of OPC-UA interfaces, plug and produce shopfloor IT, industrial challenges of data management and hyper connected ecosystems.

Production Technology Center Berlin

Application-oriented and basic research

… for the entire spectrum of industrial usage:

- Managing companies
- Developing products
- Manufacturing products with innovative manufacturing technologies, machine tools and tools
- Automating processes

Expertise at Fraunhofer IPK

Research and development for intelligent production and smart industry

Corporate and production management

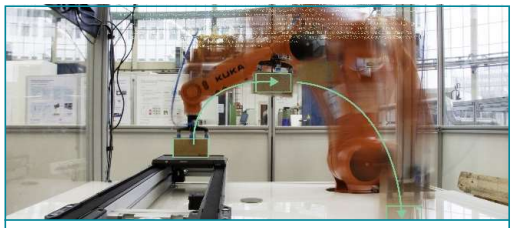
- Smart business design
- Benchmarking
- Crowd production
- Process and factory management
- Knowledge and skills management
- Workplace qualification
- Implementing innovation systems

Digital engineering

- Digital development of the future
- Digital twins
- Information factory for PLM and IoT
- Digital factory and inspection
- Smart products and services
- Model-based systems engineering

Production processes and facilities

- High-performance manufacturing
- Precision manufacturing
- Additive manufacturing
- Joining and coating
- High-performance machine tools

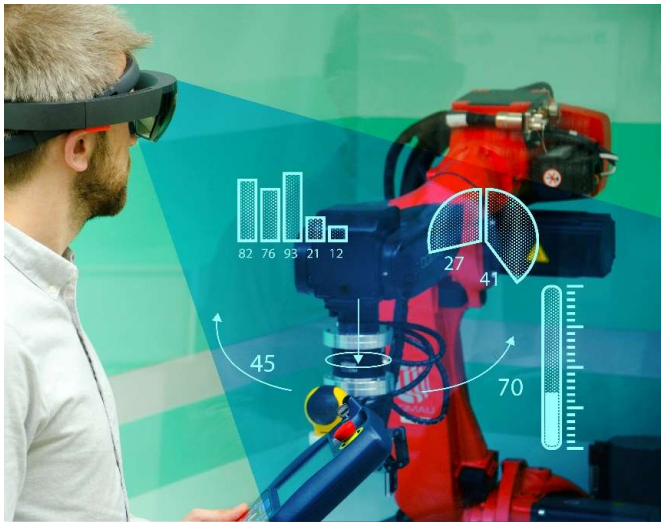


Automation

- Industrial image processing
- Virtual reconstruction
- Computer vision for safety and security
- Industrial robotics
- Process technology and optimization
- Intelligent systems for health and ergonomics

Corporate and Production Management

Managing companies flexibly



- Smart Business Design
- Development of fast Industrie 4.0 prototypes especially for SMEs
- Technology-oriented planning of Industrie 4.0 factories
- Industrie-4.0 metamorphoses with modular MES and Industrie 4.0 management cockpits
- Model-based corporate development / process management
- Digitization of business processes and introduction of holistic production systems
- Best Practice benchmarking and corporate knowledge management
- Design of global quality processes, systems and organizational structures
- Implementation of Quality 4.0 and data quality management
- Entrepreneurship and intrapreneurship (Open Lab)
- Development of national innovation systems and innovation centers

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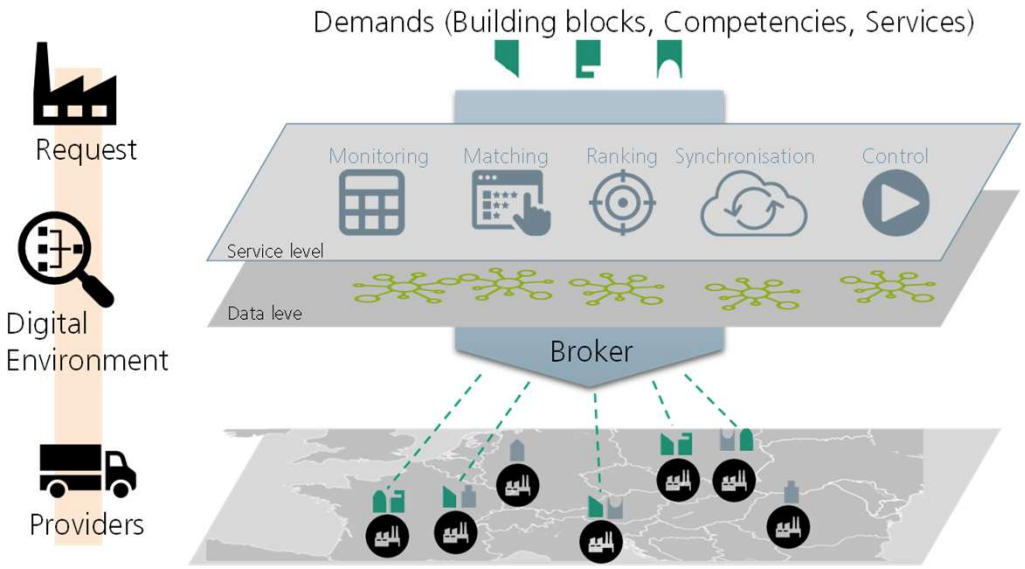
Project completed: Tenders and matching between requests and providers

Sample from research project Resyst 2020/2021 from sub workpackage “matching”



Question: How to identify and match properties of suppliers, products and services in a heterogenous world of data structures e.g. several standards for material descriptions.

Issue: Standards are related to regions, sectors, material types and its usage such as for material DIN 8580, EN 10027-2:1992-09, DIN EN 13556 and usage in automotive VDA 231-106, etc.

Identified challenge to consider in the future:
A heterogenous data world with different standard terminologies and increasing ontologies. The
Mapping to a specific ontology within a platform creates effort and costs for the potential suppliers and less acceptance.

Is every time a new ontology together with new tools required?

See also: https://www.produktion.fraunhofer.de/de/forschung-im-verbund/zukunftsthemen/RESYST/Blog/12_ModelleundPlattformenWertschoepfungsresilienz2.html

Running Project: Hyper connected Ecosystem for Industry

Sample from research project WvSC

Challenge
Where can I find partners, services, products and their data related to my current task?

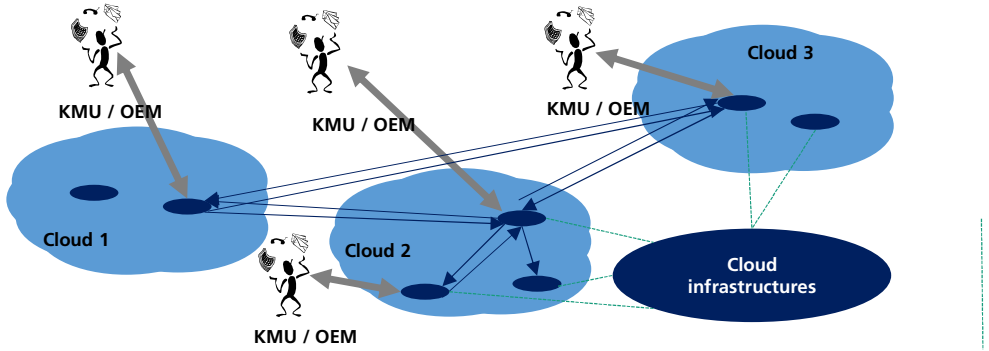
Approach:

- Semi-automatic connection of network partners
- Services to connect different clouds and data deployments

One issue is the terminology across partners because of different standards and existing ontologies.

Standards and existing ontologies approaches such as ECLASS but also approaches such as Industrial Data Space, GAIAX, BASYS has been analyzed.

Research: Werner von Siemens Centre (**https://wvsc.berlin/home-en/**) WvSC.EA "Electric motors 2.0" supported by the European Regional Development Fund (EFRE)

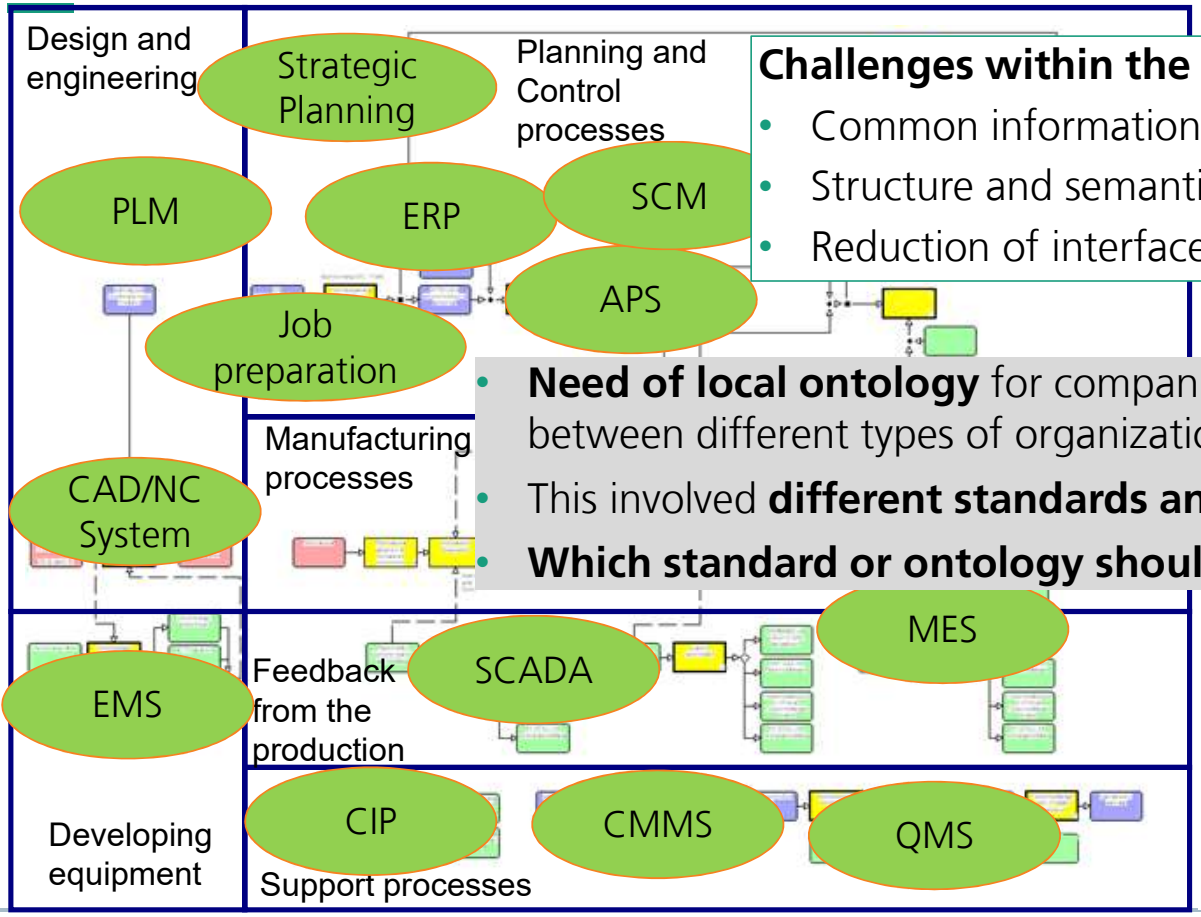


Identified challenge: After the analysis of standards, ontologies and ontology frameworks - two options appears :

1. Creation of a new ontology including/referring to existing ontologies which requires a selection and further mappings
2. **Developing a flexible concept allowing to use different standards and ontologies on demand**

Industry challange: Lots of systems with heterogenous data structures

Examples from industry projects related to master data management and system implementation



Challenges within the company:

- Common information model at least for master data management
- Structure and semantics across different IT systems and stakeholders
- Reduction of interfaces by reference ontology / master data model

- **Need of local ontology** for companies working in different fields as well as **globally** between different types of organizations.
- This involved **different standards and ontology scopes.**
- **Which standard or ontology should be selected?**

Legend:

- **SCM:** Supply chain management system
- **PLM**: Product-Lifecycle-Management
- **ERP**: Enterprise-Resource-Planning
- **APS:** Advanced Planning & Scheduling
- **MES** : Manufacturing Execution System
- **QMS**: Quality management system
- **SCADA**: Supervisory Control and Data Acquisition
- **CMMS**: Computerized Maintenance Management System
- **CIP**: System for Continual improvement process
- **EMS**: Equipment Management System
- **CAD/NC-System**: Computer-Aided Design systems
- **Job preparation**: System to define the templates for job sequences

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Examples of related standards defining or structuring terminology

Illustrating activities in research and usage in industry

Standard name and Purpose	Standard ID	Responsible Organization, TC	Acceptance and industry usage
WEB Ontolology Language OWL	OWL	W3C	Used in industry and research
Common Logic (of Meta data)	ISO/IEC 24707:2007	ISO/IEC JTC1	Accepted in academia but needs commercial tools
Top Level Ontologies	ISO/IEC 21838:2021	ISO/IEC JTC1	Accepted in academia; being exploited in international research programmes such as “Industry Ontology Foundry” and “OntoCommons”
OPC Unified Architecture to create Information Model	OPC-UA	OPC Foundation	Used in industry and used to standardise information models
Process Specification Language (for information model description) PSL	ISO 18629:2004	ISO/TC184 SC4	Accepted in industry in terms of framework for terminology development

Examples of related standards defining or structuring terminology

Illustrating activities in research and usage in industry and related activities

Standard name and Purpose	ID	Responsible Organization	Acceptance and industry usage
Formal Semantic Models for the configuration of global Production Networks	ISO 20354: 2018	ISO/TC184 SC4	Commercial tools for exploitation not available
Integration of Life Cycle Data in Oil and Gas Industry	ISO 14040:2006	ISO/TC207	Accepted in industry for Oil and Gas
EDI /EDIFACT, for data interchange in admin, commerce and transport	Edifact	Edicenter	Well accepted and used in industry
ECLASS - the worldwide ISO/IEC-compliant data standard for goods and services	ECLASS (eCl@ss old name)	ECLASS e.V.	Standardized master data - partially known in industry (https://eclass.eu/)
STEP-NC machine tool control language	ISO 10303-278:2007	ISO TC184/SC4	Well accepted and used in industry

Beside of standards approaches concerning interoperability are considered:
Industrial Data Space, GAIAX, BASYS, RAMI 4.0
BaSyx Implementation support used for prototypes: https://www.eclipse.org/basyx/

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Questions and Challenges

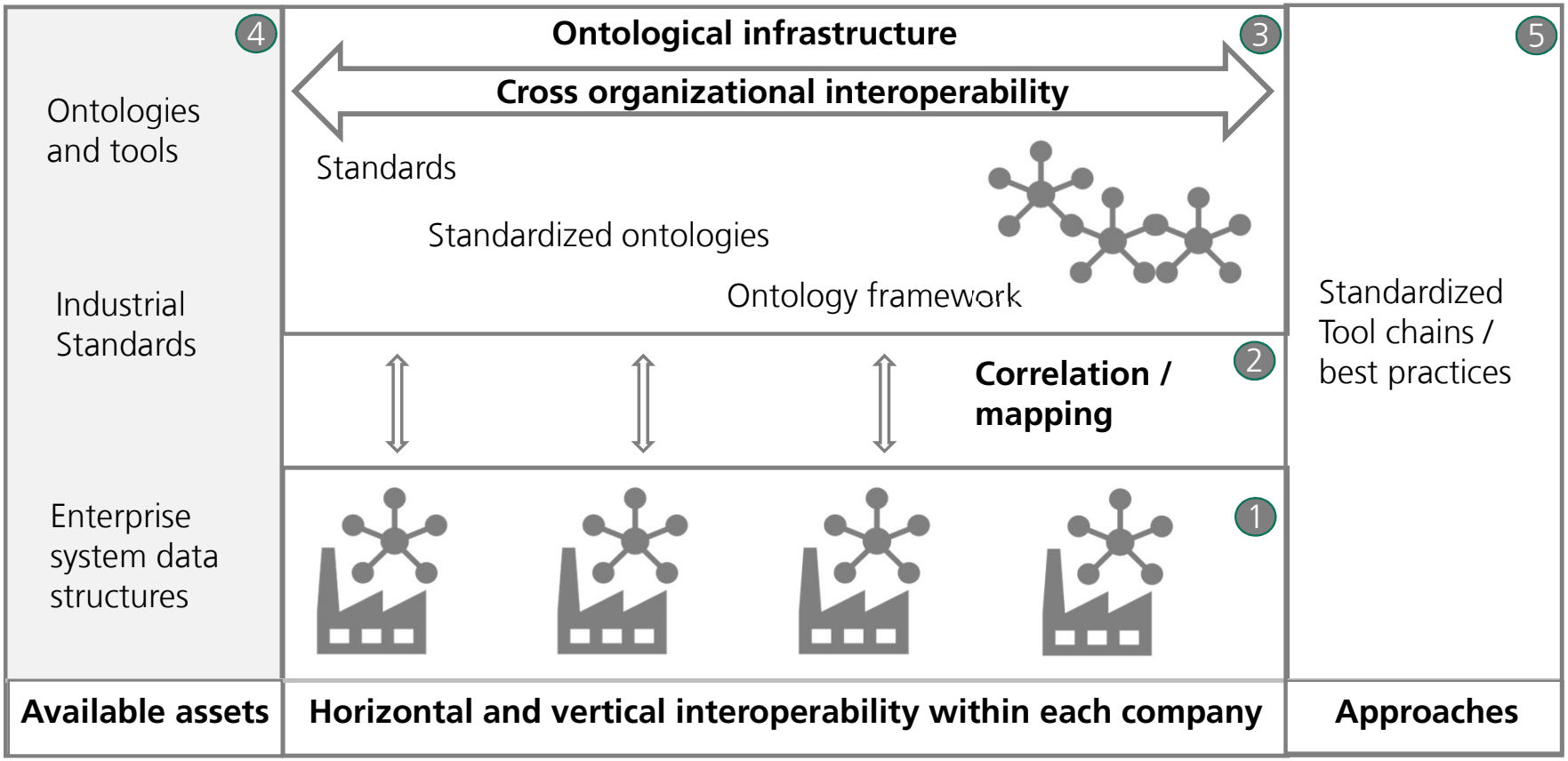
Questions related of the three cases and the situation across increasing number of standards

How to manage the current situation concerning different terminologies within standards, ontologies as well as different frameworks for ontologies ensuring flexibility for future evolutions?

- **Which standard is appropriate for a specific industrial challenge?**
- **Which is the right roadmap for industry to follow in terms of standards and ontologies?**
- **Can we provide guidelines to give a reference point for approaches and solutions?**
- **How to manage heterogeneous terminologies and data structures?**
- **How to keep independent from one major customer forcing a terminology?**

Vision idea influenced by semantic web and experiences from industry

Each company is responsible for its common data management and data publication



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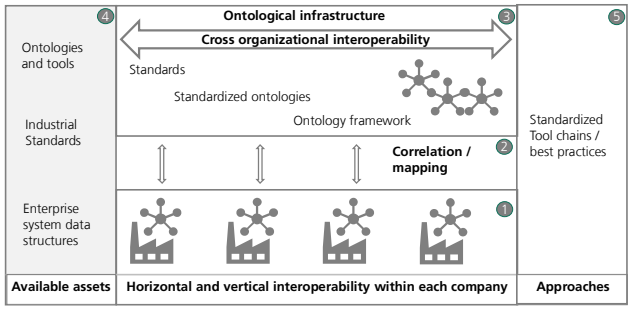

1. **Independent company ontologies to achieve improved internal interoperability e.g. enable company-wide consistent digitalization; provide common master data across the company's IT systems; simplify replacements of IT components. This structure is likely to be private and not public.**
2. **Separate mappings between the company specific ontology and the required area of the reference structure related to specific scopes. This approach would deliver independence from the standardization time horizon for the companies.**
3. **Ontological infrastructure and a reference structure for agreed interoperability across companies/enterprises.**
4. **Available standards, ontologies, information design tools and enterprise data**
5. **Approaches for the achievement of a company ontology with related methods, tools and best practises as well as mechanism to extend the ontological infrastructure.**

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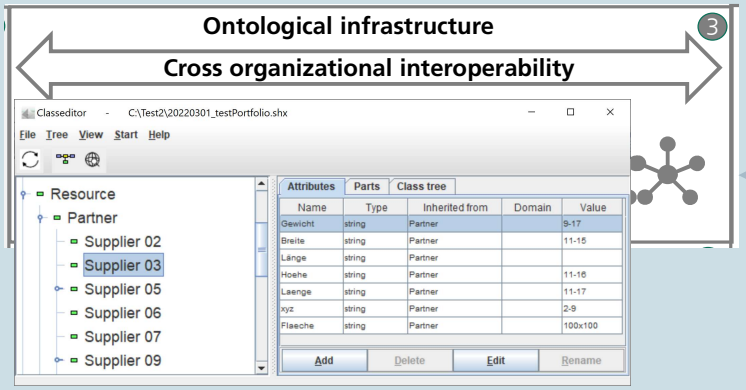
Method for initial prototype according to current feasibility of data access

The prototype is in development within the WvSC project

Global data of across organisations

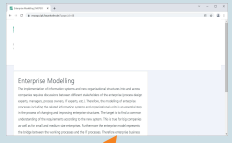


Filling / update the profile according to demand

Supported by scraper

- Profiles are defined according demands from partners about the needs for data exchange and partner correlation.
- The profiles can be related to existing standards and ontologies
- Currently the prototype supports a domain / scope specific synonym management

Local data of each organisation

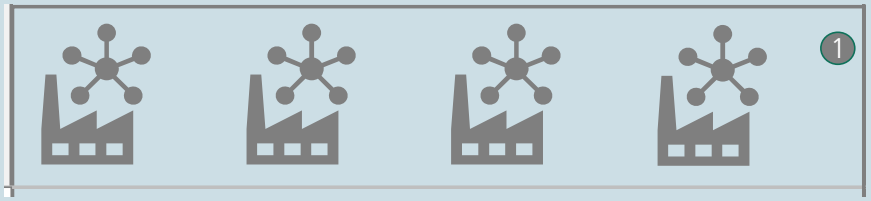


Company, product, service data – currently in table form

Web Design

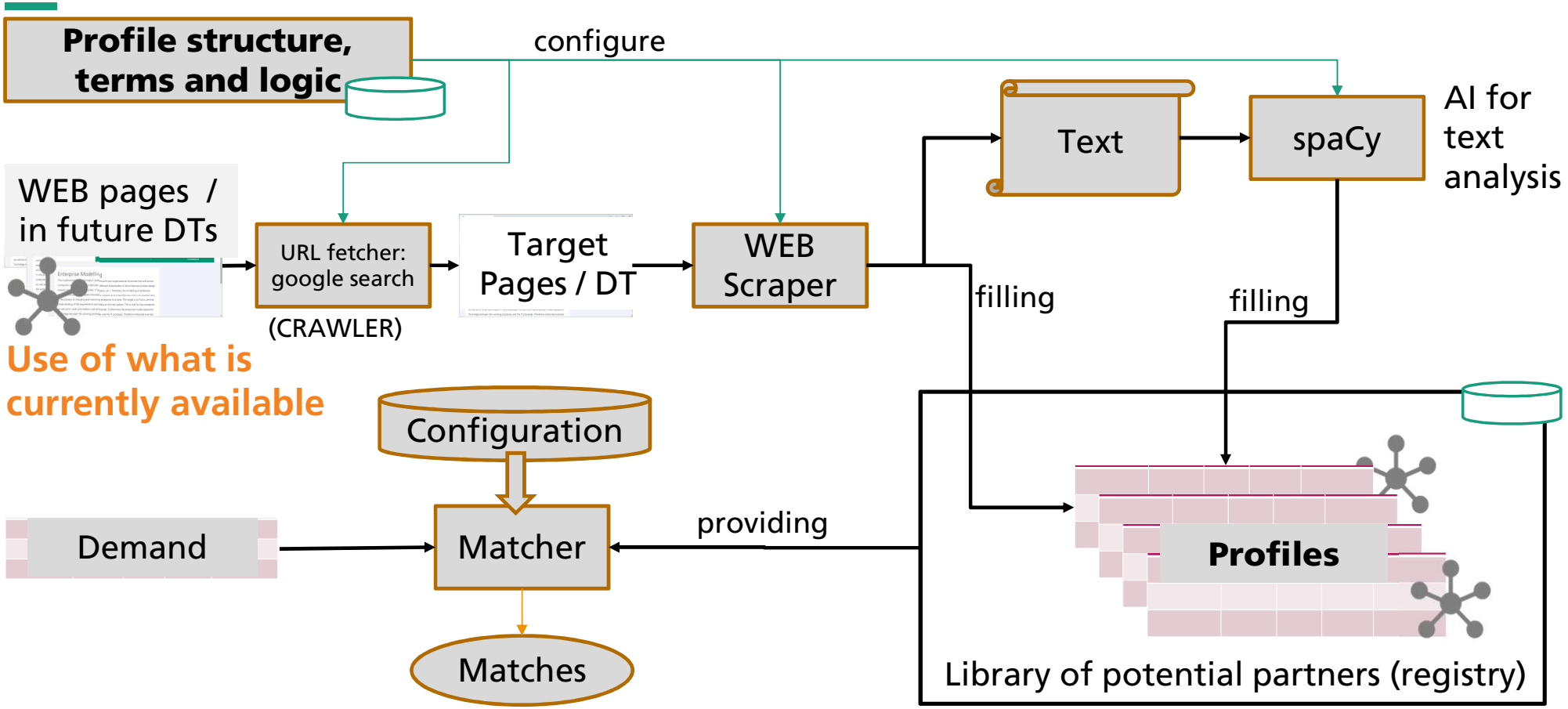
Update the data

information Distribution



Architecture of the prototype to gather the supplier data automatically

The prototype is in development within the WvSC project, initial version express the feasibility



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Conclusion

Situation

The paper proposes a reference topology of a manufacturing system reflecting

- **Industry demands, needs and benefits regarding ontologies**
- **Ontology related standards from both industry and from ISO**
- **An initial pilot (concept) built on existing work**
- **A high-level vision of the interaction between ontologies and standardization**
- **Enhancements of data exchange and interoperability**

FURTHER WORK:

- **Enhance the initial pilot**
- **Research to elaborate an ontology-oriented reference infrastructure.**
- **Roll-out to enable flexible multiple usage and use cases**